QX QX

OPERATION AND MAINTENANCE MANUAL FOR QX SERIES

SIX CYLINDER ENGINES

HERCULES MOTORS CORPORATION
CANTON, OHIO, U. S. A.

September 2, 1952

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OPERATION AND MAINTENANCE MANUAL FOR QX SERIES ENGINES

SERIAL NUMBERS { 700001- 800000
2800001-2900000

FIVE GEAR MODELS

MODEL	BORE	STROKE	NACC-H. P.	PISTON DISPL.
QXA-5	3 1/8"	x 4 1/8"	23.44	190
QXB-5	3 1/4"	x 4 1/8"	25.35	205
QXC-5	3 3/8"	x 4 1/8"	27.34	221
QXD-5	3 7/16"	x 4 1/8"	28.36	230
QXLD-5	3 7/16"	x 4 1/4"	28.36	236.7

THREE GEAR MODELS

QXA-3	3 1/8"	x 4 1/8"	23.44	190
QXB-3	3 1/4"	x 4 1/8"	25.35	205
QXC-3	3 3/8"	x 4 1/8"	27.34	221
QXD-3	3 7/16"	x 4 1/8"	28.36	230
QXLD-3	3 7/16"	x 4 1/4"	28.36	236.7

CB preceding model (CB-QXD) denotes counter-balanced crankshaft.
M or MM following model (QXDM or QXBMM) denotes Marine Engine.
C following model (QXCC-QXDC-QXDCM) denotes counter-clockwise engine.

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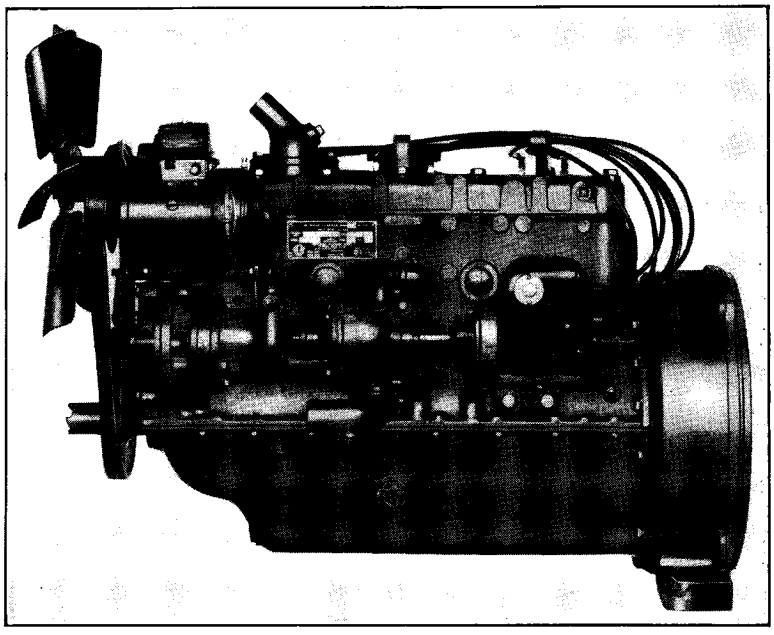
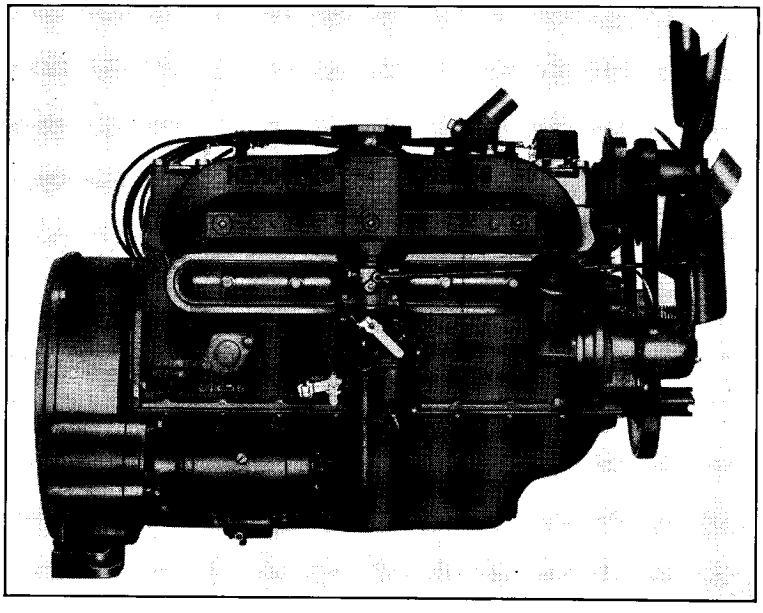


QX-5 Ignition and Water Pump Side
(Left Hand Side)



QX-5 Camshaft, Manifold and Carburetor Side
(Right Hand Side)

Introduction

The Hercules QX series engine is a six cylinder in line "L" head engine, four cycle, heavy duty, commercial type engine. The design is the result of years of development and field experience. Extensive tests have proven that these engines are adaptable to all purposes for which such sizes and types are required.

An effort has been made in this book to give sufficient information so that operators and maintenance crews can obtain the maximum efficiency and trouble free operation which may be expected of this engine.

All locations given as right hand (R.H.) or left hand (L.H.) have reference to observer's position when facing flywheel or clutch. The right hand side is the camshaft or manifold side, while the left hand side is the water pump or accessory side. The front of engine is the timing gear end. The flywheel and clutch end is the rear end of the engine. When the QX engine is used as a marine engine the power take off or reverse gear is usually attached to the timing gear or front end. Therefore, when reference is made to number one cylinder or front main bearing it is always the one nearest the timing gears. Cylinders, connecting rods, et cetera are numbered from the front or timing gear end of the engine. All dimensions are given in inches and fractions of inches except as otherwise noted. All weights and measures are in United States avoirdupois or liquid measure standards.

The book is divided into the following sections which appear in order named—Specifications, Operation, Lubrication, Trouble Shooting, Description and Maintenance, Clearances and Tools.

Where necessary to refer to accessories which are not furnished by Hercules Motors Corporation, information and comments given are general and may not apply to the specific accessory used.

As an operator you owe it to yourself to read this book carefully.

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SPECIFICATIONS

QX SERIES ENGINE

GENERAL DATA

Bore and Stroke	See Page 1
No. of Cylinders	6
N. A. C. C. Rated Horsepower	See Page 1
Piston Displacement	See Page 1

Rotation—Clockwise Standard, Looking at Cranking End.
Firing Order—1-5-3-6-2-4.
Counter-Clockwise Rotation—Optional—Looking at Cranking End.
Firing Order—1-4-2-6-3-5.

MAIN BEARINGS (PRECISION TYPE)

Material—thin babbitt, steel or brass back shell.

No. of Bearings	7
Bearing Diameter	2 1/2"
Bearing Length (Front 1)	1 5/16"
Bearing Length (Center 4)	1 15/16"
Bearing Length (Rear 7)	1 15/16"
Bearing Length (Int. 2-3-5-6)	1 7/32"

CAMSHAFT

Material—Machined steel forging, case hardened.

Drive	Helical Gear
No. of Bearings	4
Diameter of All Bearings	1 3/4"
Length (Front and Rear)	1 1/32"
Length (2-3)	9/16"

Location—Right Hand Side Looking at Flywheel.

CONNECTING ROD

Material—Heat treated nickel chrome molybdenum steel.

Connecting Rod Bearing Diameter	2"
Connecting Rod Bearing Length	1 1/4"
Connecting Rod Length, c to c	7"

MISCELLANEOUS

Cylinder and Crankcase.....Cast Integral
Cylinder Head—"L" type, detachable.
Crankshaft—Surface hardened by electric induction process.
Piston—Aluminum alloy or cast iron.
Piston Pin—7/8" Dia. steel.
Specifications of other items will be found under "Description and Maintenance" section, starting on Page 20.

GENERAL DESCRIPTION AND FEATURES OF DESIGN

CYLINDER BLOCK AND CRANKCASE

The cylinder block and crankcase are cast in one piece in order to permit more efficient cooling by water jacketing the cylinders the full length of the bore. This construction also results in a very rigid unit, which provides a sturdy support for the crankshaft.

To help distinguish the "QX-3" cylinder block from the "QX-5" cylinder block refer to Illustration No. 1. Fig. 1 shows the front of the "QX-3" block without the idler gear shaft provision while Fig. 2 shows the "QX-5" cylinder block and crankcase with provision for driving the water pump on the left hand side of engine, necessitating an idler gear to drive the water pump drive gear. Otherwise the two "QX" cylinder blocks are similar.

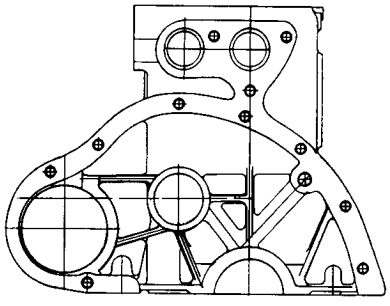

Fig. 1

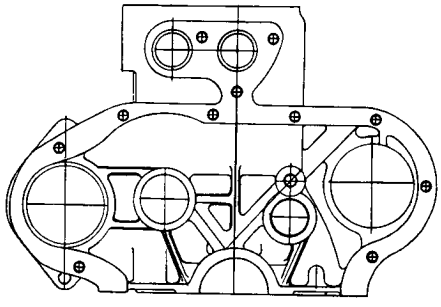

Fig. 2

Illustration No. 1

MAIN BEARINGS

The use of seven main bearings permits a main bearing being placed on each side of each connecting rod bearing (See Illustration No. 2) and this construction helps to eliminate vibration at high speeds. The center and rear main bearing caps are each held in position by four alloy steel cap screws $\frac{7}{16}$" in diameter while the remaining ones are each held by two alloy steel cap screws $\frac{1}{2}$" in diameter.

Precision or insert type bearings are used and in this construction there is a removable shell in each cap as well as for the upper part. In this type of construction the upper shell is interchangeable with the lower shell for each bearing. These shells are of the Precision type and are completely finished before being put in place and no line reaming or scraping is required. This allows renewal of bearings to be easily accomplished. The Precision type shells each have a small ear or projection which fits into a recess which allows the ear to rest against the adjoining case or cap to prevent the shell from rocking or rotating. The bearing metals commonly used in the Precision shell type bearings are harder and have a higher melting point than ordinary babbitt metal and this requires the use of a hardened crankshaft.

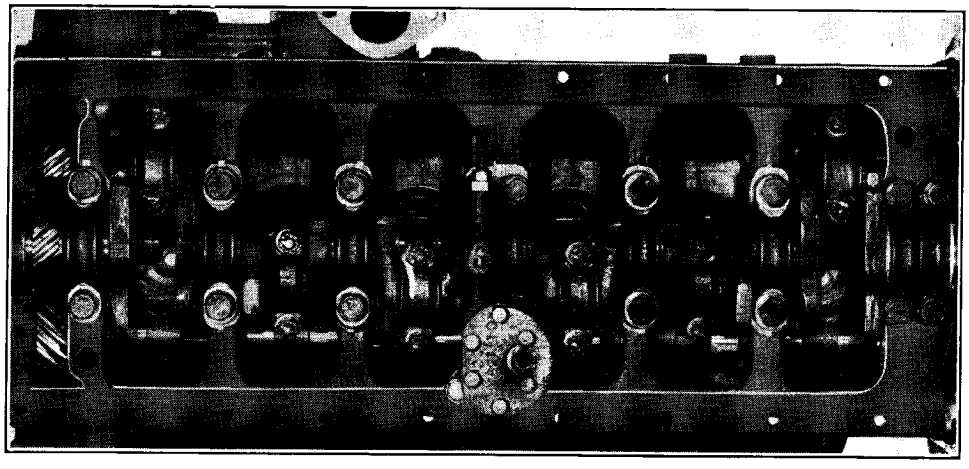

Illustration No. 2

CYLINDER HEAD

The cylinder head is of the removable type, having the major part of the combustion space over the valves and is completely water jacketed. This construction permits easy removal of the cylinder head for cleaning carbon and grinding valves.

CONNECTING RODS AND PISTONS

Like the main bearings the connecting rods have the Precision or insert type of bearing construction. In this type the cap and rod are split slightly below center so the split in the shells opposite the locking lugs does not match with the split in the forging. In some engines of this type the adjusting shims are placed on one side only, no shims being used on the side having provision for locking the shells, other engines do not have shims on either side.

The piston pin is clamped in the top end of the rod. The piston pin lock screw is prevented from working loose in early engines by a lock wire and in later engines by a shakeproof lock washer.

When cast iron pistons are used they have bronze bushings for the piston pin. The aluminum pistons do not have bushings in the pin bosses as the alloy metal of the piston forms a suitable bearing for the pin. Each piston has three compression and one oil control ring.

CAMSHAFT AND IDLER SHAFT

The camshaft is supported on four bearings in the crankcase. These bearings are of the removable babbitt lined type. At the center of the shaft is located the spiral gear which meshes with the gear attached to the oil pump shaft and drives the oil pump. There is a thrust washer placed between the cam gear and the crankcase. In the "QX-3" series there is no idler gear but in the "QX-5" the idler gear is supported by a shaft which is pressed into the gear. This shaft is supported by and turns in a babbitt lined bushing pressed into the crankcase. The idler gear is also supplied with a thrust washer between it and the case.

VALVES

The intake valve head is larger in diameter than the exhaust valve head in order to increase the efficiency and insure more power. Both intake and exhaust valves are forged from special alloy steel and the exhaust valves in particular are of high heat resisting material. Valve tappets are of the mushroom type and each is provided with suitable screw and lock nut to allow adjustment of valve stem clearance. The valve guides as well as valve tappet guides are removable bushings pressed into the cylinder block.

ACCESSORY DRIVE

On the "QX-5" engine the accessory drive or water pump is located on the side opposite that on which the camshaft and valves are located and consists of a sleeve casting bolted to the front part of the crankcase. On the "QX-3" the water pump and distributor drive are on the camshaft side.

OILING SYSTEM

The oil pump is of the gear type and is fastened to the block so that the suction end is in the oil pan and needs no priming. The oil under pressure is delivered through suitable connections to a drilled passage in the crankcase and this drilled passage extends from front to rear of the engine on the side opposite the camshaft. This passage is closed at either end by means of suitable threaded plugs. Radial holes are drilled from the crankshaft bearing to meet this horizontal oil passage and this permits oil to be delivered under pressure to the main bearings and through drilled holes in the crankshaft to the connecting rod bearings. The cylinder bores, tappets and valve stems are lubricated by means of the mist of oil thrown off around the connecting rod bearings.

In the "QX-5" the idler shaft and gear are oiled by pressure to the bushing and through drilled holes in the shaft and gear. The front camshaft bearing is oiled by pressure to the bearing. The balance of the bearings are oiled by gravity feed from oil collected in pockets.

OPERATION

This section covers those items which are of particular interest to the operator and does not cover such work as might be required of a maintenance crew. This does not mean that an operator should not acquaint himself with the various subjects covered in other sections of this book.

PRECAUTIONS
READ BEFORE STARTING ENGINE

The following precautions, if followed, will help eliminate operating difficulties and abnormal wear.

1. **Filters**—keep them clean—they are the guardians of your engine—dirty filters cause rapid wear and low engine output. Read section starting on Page 46.

2. **Fuel**—keep it clean—do not use dirty container to handle it—insist on the fuel being clean and acid free when you get it. Procure it from reputable companies.
3. **Lubricating Oil**—keep it clean—drain crankcase often. Use best brands obtainable, having specifications as set forth on Page 10.
4. Do not allow **Oil Level** to fall much below the 4/4 mark on the bayonet gauge. As the lubricating oil is the medium for removing the friction heat in the bearings, the larger the volume of oil the more heat it can absorb and dissipate. Do not fill above 4/4 or full mark.
5. **Do Not Run Engine** at any time without lubricating oil and cooling solution (water or anti-freeze mixture).
6. Do not use oil, fuel oil or kerosene in the cooling solution or as a cooling medium as these will be detrimental to the synthetic rubber water pump seal.
7. **Never Run Engine** with water or anti-freeze solution **boiling.** This allows lubrication to break down and may seriously damage engine.
8. Do not put cold water in an **Overheated Engine.** It may crack cylinder head, block, etc. An overheated engine shows negligence in operation.
9. Do not allow **Air Cleaners** to become clogged or to operate without all connections being tight. Keep them clean and properly serviced. These units protect your engine from undue wear only when they are given intelligent care.
10. Never allow your **Batteries** to run low or dry of water. The plates will warp and ruin the battery.
11. **Do Not Attempt Starting Engine** until lubricating oil, water and fuel supply has been checked and the engine properly prepared for starting. See section below.
12. **Do Not Run Engine** at high speed without load, as this will cause undue wear and shorten the engine's life.
13. **Do Not Idle Engine** for long periods as it is not only detrimental to the engine but also increases operating costs as you are using fuel without any benefit.
14. **Do Not Use Engine As a Brake** in intermediate or low gear. The high engine speeds possible when using low or intermediate gear descending steep grades will turn the engine much faster than the speed for which it is designed and damage will result unless vehicle speed is held to that used in same gears on the level.
15. **Never Allow** engine to **Run Without Oil Pressure** showing on the gauge. Damage from lack of lubrication will result.
16. Do not allow fuel in tank to run low as it may allow line to fuel pump to uncover long enough to fill the lines with air and cause the engine to stop, resulting in lost time taken for repriming.
17. Loss of power, erratic running and poor performance often results from **Air In The Fuel System or Vapor Lock.** Be sure there are no leaks in fuel lines and filters which will allow this condition to exist.
18. Remember dirt, grit, water, lint or any foreign matter in the fuel and lubricating oil is detrimental to the engine and it is your duty as an operator to see that it does not get into the engine.
19. Do not attempt to start engine in cold weather until you have read section covering **"Cold Weather Starting,"** Page 8.
20. Some external heat will help starting in cold weather and save the batteries.
21. Never run starting motor longer than 30 seconds at one time without a rest period of at least one minute before allowing it to run again. Failure to follow this procedure may result in a burnt out starting motor.
22. Do not attempt to start or operate this engine without first reading the instructions in this book carefully. As an operator you owe it to yourself.

STARTING AND OPERATING SUGGESTIONS

1. Use a good brand of fuel.
2. Use only the best lubricating oil obtainable to specifications on Page 10.
3. An S A E 30 oil is a good grade to start with (unless extreme cold weather is prevalent), from this the proper grade can be determined. See Page 10 for complete information relative to grade to use for climatic conditions encountered.
4. Fill cooling system with clean water (if in locality where water has a large percentage of dissolved minerals or is alkaline—use rain water). Allow sufficient time for water to seek lowest level, then complete filling. Run engine and recheck level.
5. Be sure the batteries are hooked up properly before pressing the starter button.
6. If possible, turn engine over three or four times by hand to be sure there is nothing sticking or water has not seeped into cylinder, as the starting motor has sufficient power to bend or break certain parts should anything be out of place.
7. Be sure all fuel line connections are tight and the fuel system properly primed.
8. Always follow starting instructions outlined below to eliminate difficulties.

STARTING THE ENGINE

First Time Started or starting engine after a long period of shut down.

1. Fill the fuel tank with suitable fuel.
2. Fill cooling system with clean pure water or if atmosphere is below freezing and engine is to stand or operate in these temperatures, use anti-freeze solution.
3. Fill crankcase with suitable lubricating oil to the 4/4 or full mark on the oil gauge rod. See lubricating oil specifications, Page 10 and Illustration No. 4 on Page 21.
4. If possible, turn engine over by means of hand crank three or four times to start oil circulation and distribute the oil already on the surfaces. This hand cranking also prevents possibilities of damage due to water having accumulated in the cylinders.
5. In addition to the procedure just described, check the lubrication of generator, starter, fan, water pump and any other accessories. Check air cleaners to make sure there are no obstructions, that they are properly installed, and are clean, and that they are properly filled with oil (if oil bath cleaners are used).
6. Check entire electrical system to be sure there are no loose connections and all component parts are properly connected together.
7. See that no loose bars, tools, parts, etc., are lying in or on any part of the engine as they could cause serious damage or wreckage of engine or bodily injury to anyone near.
8. Turn ignition switch to "On." Start engine by operating the starting motor switch. If all of the foregoing instructions have been properly followed and the proper grade and type of fuel has been used, the engine will start at once.
9. Allow engine to run for several minutes before load is applied to enable engine to properly warm up and insure proper lubrication. See Page 9 for instructions when engine is started.

Usual Routine Way Of Starting Engine. If the engine has been operating recently and nothing has been removed or repaired since it last operated, the following is all that is necessary to start:

1. Check fuel supply.
2. Check lubricating oil in engine base with gauge rod. Be sure oil is to 4/4 or full mark on rod. See Illustration No. 4.
3. Check cooling solution.
4. Inspect installation to see all is in good order and tight and no loose tools, bars or parts are lying on engine.
5. Start engine by operating starter switch after turning ignition on.
6. Check engine as under **"Operating Instructions After Starting,"** Page 9.

COLD WEATHER STARTING

At extremely low temperatures difficulty may be encountered in starting the engine due to (a) battery charge or output being low due to temperatures or (b) gasoline with vapor pressure too low to readily vaporize.

In starting any engine and particularly a cold engine do not allow it to run up to governed speed or do not run the engine much over 800 or 1000 RPM until the oil has become warm enough to circulate and the water or cooling solution has become warm enough to take the chill off the cylinder block. This usually takes four or five minutes if the engine is equipped with a thermostat. A longer period is generally required for engines not so equipped and these engines should have the radiator covered for the first few minutes in order to allow the water or cooling solution to warm up. If the unit is not equipped with a thermo-gauge or thermometer this can be then checked by placing the hand on the cylinder block or cylinder head and as soon as the engine becomes warm enough can be run up to maximum speed. This is probably the most important phase of the engine operation as damage can result in the first few seconds of running if the engine is allowed to run maximum load and maximum speed before lubrication has been established and before parts have started to warm up normally.

COLD WEATHER STARTING SUGGESTIONS

If ignition and carburetion are correct, starting in cold weather can be made less difficult by observing the following suggestions.

1. Late ignition timing causes hard starting. (Magneto impulse coupling should click or release on or slightly after top dead center).
2. Never attempt to start with wide open throttle. Have throttle open not more than one-fifth of total opening.
3. Close carburetor choke and turn engine several times before ignition switch is closed if the engine is hand cranked.
4. Close ignition switch and keep choke closed nearly all the way and crank engine over in the same way as has been followed in warmer weather.
5. When engine starts to fire keep choke partially closed until engine warms up sufficiently to run normally.
6. Filling cooling system with hot water will assist starting.
7. Thin oil such as 10W or 20W will make cranking easier.

8. Cheap gasoline makes cold weather starting very difficult.
9. Be sure gasoline flows through the carburetor. Ice may have blocked gasoline due to water in gasoline.
10. If engine has been standing idle for several days remove spark plugs and dry out and at same time pour a tablespoon of oil in each spark plug hole.

OPERATING INSTRUCTIONS AFTER STARTING

After the engine has started an inspection of the whole engine unit should be made to make sure all parts are functioning properly.

1. Look at lubricating oil gauge. If no pressure shows after engine has run 10 or 12 seconds shut down the engine and ascertain what the trouble may be.
2. Check water circulation. If no water is flowing shut down engine and ascertain what the trouble may be. Never operate with the water boiling as this heat on the cylinder walls breaks down the oil film and also causes considerable water loss due to evaporation.
3. See that no loose tools or parts are lying on or near the unit as they might fall into a place where they would cause damage or personal injury.
4. Observe engine operation for smoothness, quietness and exhaust condition. If the fuel is up to specifications and has the proper ignition qualities the engine may still run raggedly because a cylinder or two is firing irregularly due to being cold. As the engine begins to warm up, however, all cylinders should fire regularly. If they do not, trace out the trouble, some hints of which will be found starting on Page 11.
5. See that there is an adequate supply of fuel in the tank and that fuel is being delivered to the fuel pump The delivery can be checked by slightly loosening the nut connecting the supply pipe to the carburetor and if a good quantity of fuel appears it is an indication that the fuel pump is being supplied with sufficient fuel. If no fuel or very little appears, shut down the engine and check the supply tank again. If the fuel supply is adequate, check fuel line from tank to pump, for leaks from loose connections, broken nuts and cracked or broken lines. Also check lines for obstructions inside or having been pinched closed or nearly so. If lines are found satisfactory, check pump for broken diaphragm, springs and worn or broken valves.
6. Check and see that there are no oil or water leaks.
7. Clean lubricating oil filter often. This will insure maximum efficiency from this unit and does not require much time or energy to accomplish.
8. Keep all fuel filters clean and give them regular attention.
9. Observe fan and belt operation. Loose fan belts allow slippage which reduces the efficiency of the fan and wears belts out rapidly. Never allow fan to run without any lubricant but do not over-lubricate as it will throw off the excess on the surrounding parts.
10. See that radiator, if one is used, is free from obstructions between fins or tubes as they will obstruct air flow and reduce the cooling efficiency of the radiator unit.

STOPPING THE ENGINE

1. Stopping is generally effected by turning ignition switch to off position.
2. If atmospheric temperature is below freezing and no anti-freeze solution is used the complete water circulating system should be drained. This includes engine water jackets, water pump, radiator and all water pipes.
3. If anti-freeze solution is used the solution should be checked with a hydrometer to make sure the solution will not freeze. It is best to have a solution that will not freeze at temperatures far below those then being experienced.
4. Do not fill batteries with water when shutting down as this makes them more liable to freezing. Fill batteries just before starting up for the day's run.

NOTE:—If engine is kept in warm storage or is located in a warm building where freezing is not liable, 2, 3 and 4 can be disregarded.

LUBRICATION

DESCRIPTION OF LUBRICATING SYSTEM

The lubricating system on this engine is the forced feed type to all main and connecting rod bearings by means of a gear type pressure pump. The oil pump is driven through a suitable gear arrangement at the center of the camshaft. The pump picks up the oil from the center sump of the oil pan and delivers it to a drilled passage in the block. From there it flows through an oil manifold and through various leads to the main bearings. From the main bearings the oil flows through suitable drilled holes in the crankshaft to the connecting rod bearings. The bypass type pressure regulator consisting of a spring loaded piston is incorporated in the oil pump body. The idler shaft, accessory shaft and front camshaft bearings are pressure lubricated. The balance of the cam

bearings, valve tappets, valve stems and cylinders are lubricated by the mist of oil thrown off by the main and connecting rod bearings.

LUBRICATION INSTRUCTIONS

Oil Level. The level of the oil in the crankcase is determined by a bayonet or depth stick type of gauge. Wipe off gauge and reinsert to determine oil level accurately. The oil level should be maintained at or near the 4/4 mark on gauge. See Illustration No. 4.

Oil Changing. Drain the crankcase and refill with fresh oil frequently. How often this should be done depends on the operating conditions, the kind of service to which the engine is applied and whether or not the engine is equipped with a suitable oil filter. After changing the oil several times at 1000 mile or 30 hour intervals and by observing the condition of the old oil it can be determined whether the oil should be changed more frequently or less frequently. Oil should be changed more frequently when an engine is new than after it is well run in. This is because initial wearing in of various parts will result in minute metal particles in the oil which frequent draining will help to remove. The oil should also be changed more frequently in cold weather or where the engine is frequently started when cold as choking and cold running will tend to dilute the oil with unburned fuel and water. Water vapor is a product of normal combustion and this vapor will condense to form drops of water when it comes in contact with cold surfaces. Traces of water in the crankcase will therefore result from cold running and frequent oil changing will help to remove this water.

When changing oil it is not advisable to flush out the crankcase with kerosene as it is impossible to drain all the kerosene out of pockets and passages without dropping the pan and traces of kerosene will remain to dilute the fresh oil. Oil should be drained when the engine is hot as after a days run, as the oil will then be agitated and will also run more freely and carry off more sediment.

Frequent and regular oil changing together with the use of good oil is low cost insurance against expensive repairs.

Use Good Oil. The difference in cost between cheap oil and the best obtainable is money well invested as this cost will be multiplied many times when repairs are necessary due to using cheap oil. Some oils contain traces of sulphur which in itself is not harmful but when in the presence of certain products of combustion will combine to form acids which will attack the metal surfaces. It is difficult to judge the true quality of a lubricating oil except by use of elaborate equipment and prolonged tests. Therefore the best practice is to buy oil of some well known and established brand or from a company who have a reputation to maintain. The use of H. D. (Heavy Duty) oils is recommended.

Weight of Oil. In deciding what weight of oil to use it is well to obtain the recommendation of the oil company as to what weight to use for the working conditions under which the engine is operating. A suitable oil of one brand might be designated as an SAE 30 while a similar suitable oil of some other brand would have some other designation.

A lighter weight of oil should be used in a new engine during the breaking in period of 2,000 miles or fifty hours operation than can be used after the engine has been run for some time. For breaking in a new engine we suggest an SAE 20 oil for normal conditions and a lighter oil if cold weather or cold climate conditions prevail.

After the breaking in period and for normal conditions of climate and load we suggest an SAE 30 oil. For warm weather or climate conditions where the temperatures of the oil in the crankcase exceeds 220° F. the use of an oil cooler is recommended. For cold weather or climate use an oil having a pour point at least ten degrees F. below the temperature to be encountered. For example if a temperature of zero degrees F. is to be encountered the oil used should flow or pour at 10° F. below zero. Such an oil as an SAE 20W will be suitable for such conditions.

Quantity of Oil. When changing oil, approximately six to twelve quarts U. S. liquid measure are required for the "QX" engine. (Depending on type of oil pan used.) When engines are equipped with an oil filter the filter should be cleaned at the same time the oil is changed in the crankcase and about one quart more than the above mentioned quantity will be required to refill the oiling system. In such cases the oil level should be rechecked after the engine has been run long enough to refill the filter. Always use bayonet gauge when replenishing the oil supply and fill to the 4/4 mark.

ACCESSORIES

Accessories mounted on the engine usually carry their own lubricating instructions which should be followed.

OIL PRESSURE

Refer to Illustration No. 53 and No. 54, and discussion of this subject under "Oil Pressure" Page 49.

**LUBRICATION is your biggest asset to offset your greatest liability . . .
UNNECESSARY REPAIRS . . . Use only the BEST OIL obtainable.**

ENGINE TROUBLE SHOOTING

This section is devoted to giving the operator and maintenance crew some hints in tracing trouble, these suggestions being based on actual experience of servicing a great number of engines in various types of operation over a long period of time.

In order to locate trouble under different headings, refer to **"Index,"** Pages 64 and 65.

A. ENGINE MISSES INTERMITTENTLY

Cause: Spark plugs dirty, cracked or shorted by moisture on electrodes.
Correction: Clean if dirty. Replace if cracked. Dry if wet or damp.

Cause: High tension wires broken or shorted.
Correction: Replace wires.

Cause: High tension wires corroded in distributor cap.
Correction: Clean terminals.

Cause: Faulty distributor points, spark plug points, condensor or coil.
Correction: Clean and adjust or replace if necessary from spares.

Cause: Valve tappets adjusted too close.
Correction: Readjust valve tappets to correct clearance. See Illustration No. 74.

Cause: Badly worn valve guides.
Correction: Replace valve guides.

Cause: Leaking head gasket.
Correction: Tighten cylinder head nuts to proper tension or replace gasket if necessary.

Cause: Warped or cracked cylinder head usually due to overheating or pouring cold water in an overheated engine.
Correction: Replace cylinder head.

Cause: Cracked valve seat or water jacket usually indicated by overheating and loss of cooling solution.
Correction: Replace cylinder block.

Cause: Air leak in intake manifold.
Correction: Replace gaskets or manifold if necessary.

B. LOSS OF POWER

Cause: Motor missing intermittently.
Correction: See part A above for cause and correct.

Cause: Motor out of time.
Correction: Retime ignition system, See Pages 42 and 43.

Cause: Valves or valve seats worn and leaking.
Correction: Regrind valves. See section starting on Page 55.

Cause: Piston rings broken, stuck in grooves or worn.
Correction: Replace rings and clean ring grooves in piston.

Cause: Tappets sticking or set too close.
Correction: Readjust tappets or if sticking, remove and clean.

Cause: Worn pistons, rings, et cetera.
Correction: Replace worn parts or rebuild engine.

Cause: Spark plugs leaking.
Correction: Tighten spark plugs in head.

Cause: Worn cylinders.
Correction: Rebore cylinders and install new oversize pistons and rings

Cause: Worn valve stems or guides.
Correction: Replace valves or guides.

Cause: Valve springs weak or broken.
Correction: Replace springs.

Cause: Valve timing incorrect.
Correction: Correct timing, see Page 23.

Cause: Poor carburetor action.
Correction: Clean or repair carburetor.

Cause: Water or sediment in fuel tank or filter.
Correction: Clean fuel system.

Cause: Air cleaner clogged.
Correction: Wash element in suitable cleaning solution such as gasoline, fuel oil, et cetera.
Cause: Exhaust pipes or muffler restricted.
Correction: Clean or replace exhaust pipe, muffler or tail pipe.

C. ENGINE KNOCKING

Cause: Loose or worn main bearings.
Correction: Replace main bearings.
Cause: Loose or worn connecting rod bearings.
Correction: Adjust or replace bearings.
Cause: Loose piston pins.
Correction: Replace pins with oversize pins or piston and pin assembly.
Cause: Worn cylinder bores and pistons.
Correction: Rebore cylinders and install new oversize pistons.
Cause: Tight piston pins.
Correction: Fit pins to proper clearance. See Pages 49 and 62.
Cause: Tight pistons.
Correction: Fit pistons to proper clearance. See Pages 49 and 62.
Cause: Overheated engine.
Correction: Allow engine to cool, then determine cause of overheating. See paragraph E-1, Page 13.
Cause: Lack of lubricating oil.
Correction: Fill crankcase with proper grade and quantity of oil. If engine still knocks, check and replace bearings.
Cause: Loose flywheel.
Correction: Tighten in place; if worn excessively by running loose, replace.
Cause: Excessive end play in camshaft.
Correction: Adjust with screw in gear cover. See Page 39.
Cause: Idler gear shaft has excessive end play.
Correction: Adjust with screw in gear cover. See Page 39.
Cause: Bent connecting rod.
Correction: Check and straighten or replace if necessary.

D. FUEL SYSTEM

1. **Excessive fuel consumption. This is usually accompanied by increased lubricating oil consumption due to dilution of the oil.**

Cause: Carburetor worn or not properly adjusted. Indicated by black smoke in exhaust.
Correction: Check and repair carburetor.
Cause: Fuel leaks.
Correction: Check fuel tank, lines, connections, et cetera.
Cause: Sticking controls.
Correction: Oil controls and eliminate binding.
Cause: Excessive idling of engine.
Correction: Shut off engine when not in operation.
Cause: Excessive use of choke.
Correction: Warm engine to operating temperature before applying load if possible; also keep choke mechanism properly adjusted.
Cause: Dirty air cleaner accompanied by lack of power.
Correction: Clean air cleaner.
Cause: Engine overheating.
Correction: See Overheating under **"Cooling System,"** paragraph E-1, Page 13.
Cause: Engine in poor condition and adjustment.
Correction: Overhaul engine.
Cause: Poor or weak ignition indicated by engine misfiring and puffs of smoke from the exhaust.
Correction: See **"Ignition System,"** paragraph G-3, Page 16.
Cause: Dirty and improperly adjusted spark plugs.
Correction: Clean and adjust.
Cause: Engine over-cooling.
Correction: See **"Cooling System,"** paragraph E-2, Page 14.

2. Fuel pressure too low.

Cause: Air leak in system.
Correction: Tighten connections and check supply lines for leaks, replace if necessary.
Cause: Fuel pump diaphragm out of order also causing increased lubricating oil consumption due to oil dilution.
Correction: Replace diaphragm. See **"Fuel Pump,"** section starting on Page 34.
Cause: Fuel pump rocker arm linkage worn.
Correction: Rebuild the fuel pump, See Page 34, or replace from spares.
Cause: Fuel pump check valves and springs not functioning properly.
Correction: Clean or replace valves and springs.

3. Lack of fuel at carburetor.

Cause: Empty fuel tank.
Correction: Fill tank with fuel.
Cause: Bent, kinked or broken fuel lines.
Correction: Straighten or replace lines.
Cause: Dirty filtering screens.
Correction: Clean the filter screen. When replacing element in fuel filter, tightening the clamp nut finger-tight is sufficient.
Cause: Fuel leaks.
Correction: Check tank, lines, connections, et cetera.
Cause: Broken fuel pump diaphragm.
Correction: Replace diaphragm. See **"Fuel Pump,"** Page 34.
Cause: Sticking fuel valve in carburetor.
Correction: Replace fuel valve and seat.
Cause: Loose fuel pump cover plate screws.
Correction: Tighten screws.

4. Improper idling.

Cause: Sticking control rods or linkage.
Correction: Oil connections and eliminate binding.
Cause: Idling screw not properly adjusted.
Correction: Adjust screw for even idling.
Cause: Carburetor fuel and air mixture not properly adjusted.
Correction: Adjust carburetor.

E. COOLING SYSTEM

1. Overheating

Cause: Lack of cooling solution, water, anti-freeze, et cetera.
Correction: Refill system with proper solution.
Cause: Fan belt not properly adjusted.
Correction: Adjust fan belt for approximately 1" deflection.
Cause: Carburetor choke valve partly closed.
Correction: Adjust choke valve or controls.
Cause: Thermostat sticking in closed position.
Correction: Clean and test or replace.
Cause: Coating of calcium salts on cylinders and inside of cooling system.
Correction: Clean and flush cooling system. The use of a good commercial type inhibitor is recommended by the manufacturer of the radiator.
Cause: Dirt or insects in radiator air passages.
Correction: Clean or blow out with compressed air.
Cause: Hoses deteriorated. Cannot always be determined by condition of outside covering.
Correction: Replace hose.
Cause: Inlet or outlet hoses collapsing.
Correction: Replace hoses, using hose with an inner support if necessary.
Cause: Water pump not functioning.
Correction: Check and replace drive shaft, impeller, supply lines, et cetera.
Cause: Exhaust pipes restricted, usually noted by hissing sound in exhaust.
Correction: Clean pipes and remove restriction.

2. Over-cooling

Cause: Thermostat sticking open.
Correction: Clean and test or replace thermostat.
Cause: Weather or climatic conditions too cold to allow thermostat to hold temperature.
Correction: Cover radiator sufficiently to bring water temperature into proper range or use winter front.

3. Loss of cooling water

Cause: Leaks in radiator core.
Correction: Repair or replace.
Cause: Defective hose connections.
Correction: Tighten clamps or replace hose or clamps.
Cause: Radiator tubes clogged.
Correction: Clean or replace.
Cause: Water pump seals defective.
Correction: Replace seals. See Section starting Page 58.
Cause: Loose expansion plugs (core plugs) in cylinder block.
Correction: Tighten or replace plugs.
Cause: Cracked cylinder head or block. Blown cylinder head gasket.
Correction: Replace.

F. CLUTCH ASSEMBLY

1. Slipping

Cause: Improper adjustment.
Correction: Adjust.
Cause: Weak pressure spring.
Correction: Replace spring.
Cause: Sticking release sleeve.
Correction: Check sleeve and pressure spring.
Cause: Worn facings on driven disc assembly.
Correction: Replace facings or disc assembly.
Cause: Facings saturated with oil.
Correction: Clean facings and correct cause. Check oil seal in bellhousing, also pilot on flywheel. Do not over-lubricate clutch shafts, bearings, et cetera.

2. Chattering

Cause: Oil on facings.
Correction: Clean or replace facings.
Cause: Sticking release sleeve.
Correction: Check pull back spring. If broken, replace.

3. Rattling

Cause: Loose release fork.
Correction: Tighten fork.
Cause: Weak or broken pull back spring.
Correction: Replace spring.
Cause: Improper pedal adjustment.
Correction: Adjust pedal.

G. ELECTRICAL SYSTEM

1. Starting motor

(a) **Slow cranking speed** may be caused by

Cause: Crankcase lubricating oil too heavy or cold.
Correction: Change to correct grade of oil or heat the oil before attempting to start the engine, see Page 8.
Cause: Loose or dirty cable connections.
Correction: Clean and tighten.
Cause: Worn brushes.
Correction: Replace brushes.
Cause: Dirty or worn armature.
Correction: Clean, repair or replace armature.

Cause: Armature rubbing field coils.
Correction: Replace starter shaft bushings.
Cause: Low battery voltage.
Correction: Check generator and regulator then recharge battery.

(b) Starter failing to operate may be caused by

Cause: Battery discharged.
Correction: Recharge battery.
Cause: Burned circuit breaker.
Correction: Replace circuit breaker.
Cause: Broken battery cables.
Correction: Replace cable.
Cause: Poor connections.
Correction: Clean and tighten.
Cause: Burned commutator bars.
Correction: Recut commutator.
Cause: Open or short circuits in armature or fields.
Correction: Check and repair.
Cause: Defective starter switch (Push button or Solenoid).
Correction: Check and repair contacts or replace switch.

2. Generator

(a) Low or no output

Cause: Fully charged battery.
Correction: None. Check output when battery is slightly discharged.
Cause: Dry battery.
Correction: Refill with distilled water.
Cause: Burned contacts on regulator units.
Correction: Clean or replace contacts.
Cause: Grounded armature wires or terminal posts.
Correction: Replace wires and insulate terminals.
Cause: Burned commutator bars.
Correction: Recut commutator.
Cause: Worn or sticking brushes.
Correction: Clean or replace brushes.
Cause: Open circuits in field or armature.
Correction: Repair or replace defective parts.
Cause: Brush springs weak or improperly adjusted.
Correction: Adjust or replace springs.
Cause: Rough, dirty or greasy commutator bars.
Correction: Clean commutator bars.
Cause: High mica on commutator.
Correction: Undercut mica.
Cause: Commutator out of round.
Correction: Recut commutator.

(b) Noisy generator

Cause: Loose mountings.
Correction: Tighten mounting bolts.
Cause: Worn or loose drive pulley.
Correction: Tighten or replace pulley.
Cause: Worn bearings.
Correction: Replace bearings.

(e) Excessive output.

Cause: Generator field grounded.
Correction: Check wires, et cetera for external ground.
Cause: Regulator circuit breaker closed.
Correction: Adjust or repair circuit breaker. Check generator for damage.
Cause: Defective regulator.
Correction: Replace the regulator.

3. **Ignition system—distributor, coil and spark plugs.**

(a) Engine will not start

Cause: Breaker points not closing.
Correction: Check and adjust.
Cause: Breaker points defective.
Correction: Check and replace, if necessary.
Cause: Breaker arm grounded.
Correction: Replace arm.
Cause: Defective cap or rotor.
Correction: Check and replace.
Cause: Defective coil.
Correction: Replace coil.
Cause: Defective condenser.
Correction: Replace condenser.
Cause: Loose terminals or grounded wires.
Correction: Check and tighten or replace.

(b) Engine misses at low speed.

Cause: Breaker point gap too small.
Correction: Check and adjust gap to proper setting. See Pages 42 and 43.

(c) Engine misses at high speed.

Cause: Breaker arm spring tension too weak.
Correction: Replace spring or spring and arm.
Cause: Breaker point gap too large.
Correction: Adjust gap.

(d) Engine pings excessively under load at high speed.

Cause: Timing too far advanced or incorrectly set.
Correction: Check and properly adjust. See Pages 42 and 43.
Cause: Inferior grade of fuel.
Correction: If it is impossible to obtain the proper grade of fuel, it may be necessary to retard the spark or distributor timing somewhat to overcome the pinging noise.

(e) Weak spark at plugs.

Cause: Breaker contact points worn or defective.
Correction: Examine, repair or replace the points.
Cause: Condenser disconnected or defective.
Correction: Test connection or replace condenser.
Cause: Breaker cam worn.
Correction: Install new cam and stop plate assembly.

(f) Engine lacks speed and overheats.

Cause: Breaker cam retarded.
Correction: Readjust distributor and advance arm.

(g) Timing incorrect or irregular.

Cause: Breaker cam loose.
Correction: Examine distributor governor weights, pivots, springs, shaft, et cetera. Replace as necessary.

(h) Breaker points pitted or burnt.

Cause: Grease or dirt on points.
Correction: Clean, repair or replace.
Cause: Defective condenser.
Correction: Replace condenser.

(i) Engine misses at all speeds.

Cause: Distributor points set too far apart.
Correction: Check and adjust.
Cause: Condenser defective or disconnected.
Correction: Check connection, replace condenser if necessary.
Cause: Breaker point screw lock nut loose.
Correction: Adjust points and tighten.

Cause: Breaker points burnt, oxidized or unevenly spaced.
Correction: Check, clean and adjust; replace if necessary.

H. EXCESSIVE SMOKE FROM EXHAUST

Cause: Too much oil in crankcase.
Correction: Fill only to 4/4 mark on bayonet gauge.
Cause: Carburetor float sticking or fuel valve leaking.
Correction: Adjust or replace fuel valve and seat. Examine float for leaks.
Cause: Worn pistons, rings or cylinders.
Correction: Replace worn parts or overhaul engine.

I. EXCESSIVE OIL CONSUMPTION

Cause: Oil leaks at gaskets, screws, oil seals, et cetera.
Correction: Tighten or replace gaskets, et cetera.
Cause: Inferior grade of oil.
Correction: Use a good quality oil. See specifications.
Cause: Overheating.
Correction: Refer to Item 1 under **E.**
Cause: Ring gaps too great or lined up.
Correction: Install new rings. If ring gaps are lined up, the condition will correct itself.
Cause: Worn or broken rings.
Correction: Replace rings.
Cause: Cylinder bores out of round or excessive taper.
Correction: Rebore cylinders, install new pistons, rings, et cetera.
Cause: Main or connecting rod bearings loose.
Correction: Adjust or replace bearings.
Cause: Oil ring slots clogged with carbon.
Correction: Clean rings. Replace if necessary.
Cause: Carburetor fuel mixture too rich.
Correction: Replace worn jets and adjust.
Cause: Piston improperly fitted or installed.
Correction: Correct or replace piston. See Page 49.
Cause: Piston rings improperly fitted in piston grooves or cylinder bores.
Correction: Fit rings properly in grooves and cylinders. See Pages 49 and 50.
Cause: Air cleaner not clean, allowing dirt to enter combustion chamber with resultant wear.
Correction: Keep air cleaner clean.

J. BEARING FAILURES

Cause: Continuous overspeeding of the engine.
Correction: Continuous operation at maximum speed or close to it is to be avoided. Exercise caution when going down grade. Do not allow vehicular speed to exceed same speed obtainable in same gear on level terrain
Cause: Lack of oil.
Correction: Keep oil level at 4/4 mark on bayonet gauge.
Cause: Inferior grade of oil or oil of improper viscosity.
Correction: Use good quality oil of proper viscosity.
Cause: Low oil pressure.
Correction: Adjust oil pressure. See Page 49.
Cause: Bent connecting rod.
Correction: Replace connecting rod.
Cause: Crankshaft rough or out of round.
Correction: Regrind or replace shaft.
Cause: Restricted oil passages.
Correction: Clean oil lines and passages.
Cause: Bearings loose or improperly fitted.
Correction: Adjust or replace main or connecting rod bearings.
Cause: Dirt or other matter in lubricating oil.
Correction: Use clean oil and service breather air filter regularly. Replace oil filter cartridges or elements.

K. LOW OIL PRESSURE

Cause: Oil pump strainer screen in oil pan clogged.
Correction: Clean screen.
Cause: Oil too hot, resulting in low viscosity.
Correction: Correct cause of overheating.
Cause: Pressure regulator piston worn or clogged with carbon.
Correction: Clean and adjust properly. See page 49
Cause: Excessive main and connecting rod bearing clearance.
Correction: Adjust or replace bearings.
Cause: Oil pressure gauge defective.
Correction: Replace gauge.
Cause: Oil pressure gauge line bent or clogged.
Correction: Clean, straighten or replace line.

L. RAPID CYLINDER OR PISTON WEAR

Cause: Breather and air cleaner not properly serviced, allowing dirt and abrasives to enter combustion chambers.
Correction: Clean frequently and at regular intervals.
Cause: Inferior grade of lubricating oil.
Correction: Use good quality oil. See specifications, Page 10.
Cause: Lack of oil.
Correction: Keep oil level at 4/4 mark on bayonet gauge.
Cause: Dirty oil.
Correction: Replace or change oil and replace oil filter elements.
Cause: Piston rings not properly fitted to cylinders.
Correction: Replace piston rings. See Pages 49 and 50.
Cause: Carburetor fuel mixture too rich.
Correction: Replace worn jets.
Cause: Cold operation of engine.
Correction: Check thermostat. Warm engine before applying load.

M. VALVES STICKING

Cause: Incorrect valve tappet clearance.
Correction: Adjust clearance correctly. See Page 58.
Cause: Valve springs weak or broken.
Correction: Replace springs.
Cause: Valve stems or guides scored, dirty or gummy.
Correction: Clean, polish or replace.
Cause: Incorrect clearance between valve stem and guide.
Correction: Fit valve stems to correct clearance in guides.

N. BURNT VALVES OR VALVE SEATS

Cause: Valve tappet clearance adjusted too close.
Correction: Adjust valves to proper clearance.
Cause: Weak valve springs.
Correction: Replace.
Cause: Excessive carbon.
Correction: Remove carbon deposits.
Cause: Camshaft not timed correctly.
Correction: Retime camshaft. See Page 23.
Cause: Lean fuel mixture.
Correction: Clean and adjust carburetor.
Cause: Valve seats too narrow.
Correction: Cut seats to correct width.
Cause: Low grade fuel.
Correction: Use good quality fuel.
Cause: Valve heads cut too thin when refacing.
Correction: Replace valve.

O. SPARK KNOCK OR PING

Cause: Excessive accumulation of carbon in combustion chamber.
Correction: Clean or remove carbon deposits.
Cause: Hot spot in combustion chamber due to carbon deposit or clogged water passage.
Correction: Remove carbon and open water passage.
Cause: Motor operating too hot.
Correction: See **"Cooling System," E-1.**
Cause: Inferior type fuel.
Correction: Use good quality fuel.
Cause: Ignition timing incorrect.
Correction: Correct or reset timing.
Cause: Carburetion or fuel mixture incorrect.
Correction: Check carburetor.
Cause: Spark plug gaps too wide.
Correction: Adjust gaps correctly.

P. EXPLOSION IN MUFFLER

Cause: Ignition timing too late.
Correction: Correct ignition timing.
Cause: Weak spark.
Correction: Check condenser, distributor, coils, wires, et cetera.
Cause: Exhaust valves holding open.
Correction: Check tappet clearance, springs, guides, et cetera.
Cause: Exhaust valves warped.
Correction: Reface or replace.

Q. EXPLOSION IN CARBURETOR OR AIR CLEANER

Cause: Fuel mixture too lean.
Correction: Clean carburetor, check fuel level in bowl.
Cause: Intake valves holding open.
Correction: Check tappet clearance, springs, guides, et cetera.
Cause: Intake manifold leaking.
Correction: Tighten manifold nuts or replace gaskets.

REMEMBER

Good Oil changed frequently . . . . . .
Oil Filter Elements replaced often . . . . .
Breather and Air Cleaner kept clean and functioning properly . . . . . .
Engine in good adjustment . . . . . .

Mean Longer Life to the Engine and Trouble-Free Operation

DESCRIPTION AND MAINTENANCE

This section covers a brief description and function of the various parts of the engine along with complete instructions covering the repair, disassembly and reassembly of these various component parts of the QX series engine.

This section has the various subjects arranged alphabetically for convenience in locating.

AIR CLEANERS

Since dirt is the greatest enemy of any internal combustion engine, it is necessary to take every precaution to prevent it from entering the engine. Therefore one of the most essential preventative measures is proper maintenance of the carburetor air intake air filter. These units should be cleaned at least once a day or if operating in very dusty conditions it should be cleaned every six or eight hours. All connections between the air cleaner and carburetor must be air tight. It is possible, under certain conditions, for enough abrasive laden air to be drawn into the engine through a loose connection to cause rapid wear of the pistons, piston rings and upper cylinder surfaces.

The screen type air cleaner should be removed and washed in gasoline or kersosene, then dipped in clean lubricating oil and replaced on the engine.

The oil bath type air cleaner should be serviced as outlined below.

Illustration No. 3

Each 100 or 150 hours or until a satisfactory schedule can be worked out, depending on actual operating conditions, the complete air cleaner should be removed from the engine and thoroughly washed and cleaned. (This operation should not be necessary if the oil cup or screen has been cleaned daily.) A dirty, clogged air cleaner causes loss of power, excessive fuel consumption and dilution of the lubricating oil from the excess fuel.

The air cleaner element must be clean to allow free passage of air or the air cleaner will act as a choke which would cause a rich carburetor mixture and excessive crankcase dilution and loss of power. Clean as follows:

1. Unscrew the winged nut or knurled knob on top of the filter, and lift the screen and cover from the filter.

2. Wash the screen in clean kerosene, fuel oil or gasoline. If compressed air is available, blow dry, blowing from inside to outside. If after first washing it still appears dirty, wash again and repeat until clean. Lay this unit after it is clean on a piece of clean paper.

3. Remove lower shell, empty the oil, and wash the shell as above. Some of these units have a baffle plate in the bottom; remove this before cleaning as most of the dirt will be found under this plate.

4. Replace lower shell and baffle, if used, and fill with clean lubricating oil (same grade as used in engine or S.A.E. 10) to bead, as indicated by arrow in Illustration No. 3.

5. Before installing the screen inspect gasket and if torn or broken, replace. Now dip the screen or unit in clean lubricating oil and install. This operation is essential since this unit if unoiled will absorb the oil from the lower unit thus reducing the amount of oil to a point which efficient air cleaning action is no longer available.

BATTERY IGNITION DISTRIBUTOR DRIVE

(See Water Pump)

BAYONET GAUGE

The bayonet gauge is used to determine the amount of oil in the oil pan and is readily accessible. See Illustration No. 4. The oil level in the oil pan should always be maintained at or near the 4/4 mark, Illustration No. 4. Never allow level to go below 2/4 mark.

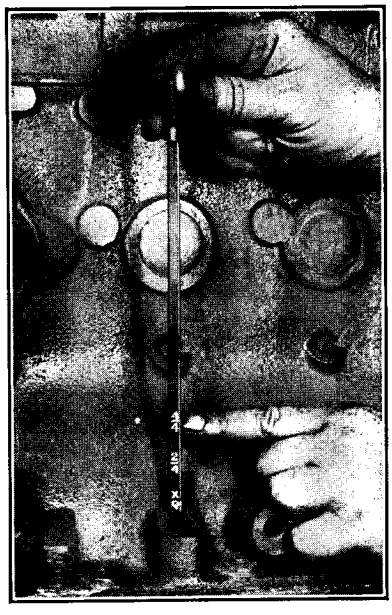

Illustration No. 4

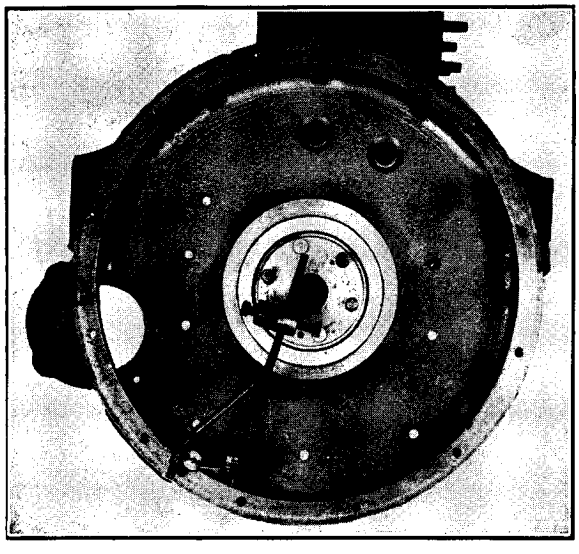

Illustration No. 5

BELLHOUSING OR FLYWHEEL HOUSING

The bellhousing is a casting which not only covers the rear end of the block and oil pan but also forms a housing for the flywheel and clutch. It also is the rear motor support and to it the transmission is fastened.

REMOVING BELLHOUSING

1. Drain crankcase oil.
2. Remove clutch.
3. Remove flywheel. See Illustration No. 28.
4. If engine is in unit, place suitable supports under the rear of oil pan to support engine. Block must be large enough so that oil pan is not damaged. Do not use jack unless large block is placed between jack screw and oil pan.
5. Remove rear motor support screws.
6. Remove bellhousing attaching screws.
7. Pull bellhousing away from engine. It may be necessary to tap housing with a soft hammer to loosen from saddle or gasket sticking to block.

INSTALLING BELLHOUSING

1. Cement new gasket to bellhousing, allowing cement to dry sufficiently so gasket will not skid.
2. Assemble bellhousing to engine. Tighten the screws so that they are almost tight.
3. With dial indicator mounted as shown in Illustration No. 5, check concentricity of bellhousing bore with crankshaft. (This should be within .010″.) The bellhousing may be shifted slightly on the screws if necessary. When bellhousing is properly centered, tighten attaching screws and install rear motor support screws. Recheck after tightening, as housing may have moved during this operation.
4. Set indicator as shown in Illustration No. 6 and check face of bellhousing. This should not exceed .006″, out of square.

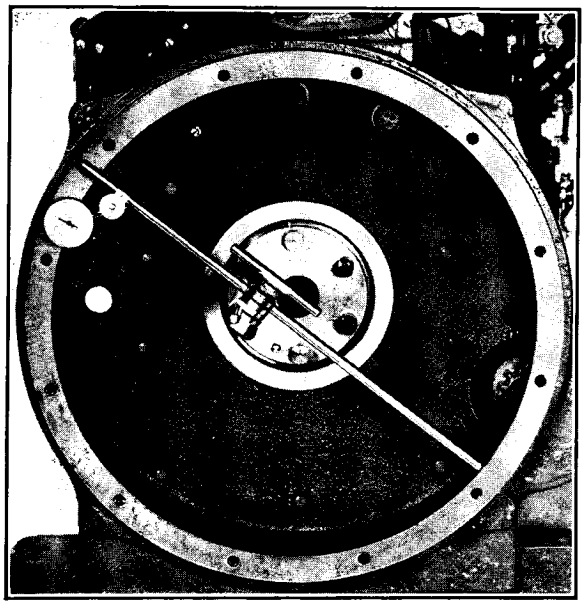

Illustration No. 6

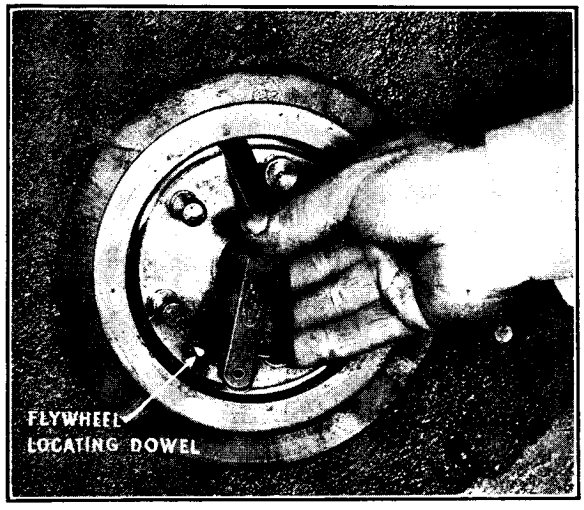

Illustration No. 7

5. With the crankshaft pushed to the rear of the engine, check bellhousing to crankshaft chamfer clearance. This should be from .014" to .020". Illustrations No. 7 and No. 9.
6. Install new oil seal in bellhousing. Illustration No. 8.
7. Inspect flywheel oil seal surface for any possible nicks or rough places. A piece of Crocus cloth or very fine emery cloth may be used to polish this surface. Illustration No. 9.
8. Assemble flywheel to engine. (A thin coating of oil soap applied to the oil seal will be found beneficial during the run-in period.)
9. Assemble clutch to flywheel.

BREATHER AND OIL FILLER

The breather is used to keep dust and dirt from entering the crankcase. It must be serviced regularly. It is very easy to service and should be cleaned daily.

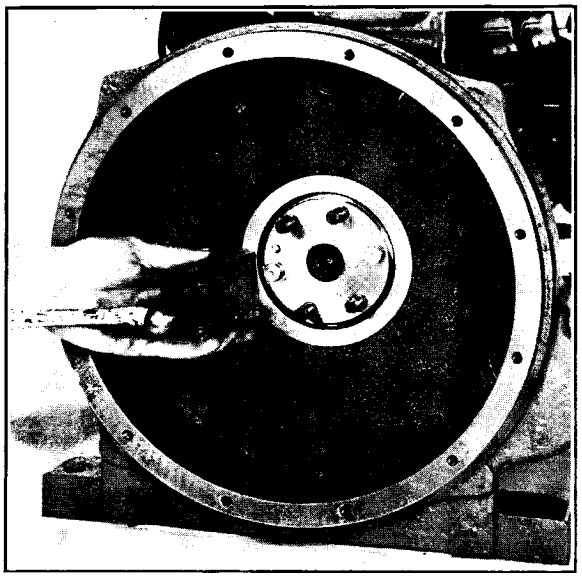

Illustration No. 8

TO CLEAN

1. Remove accumulated dirt from outside of breather.

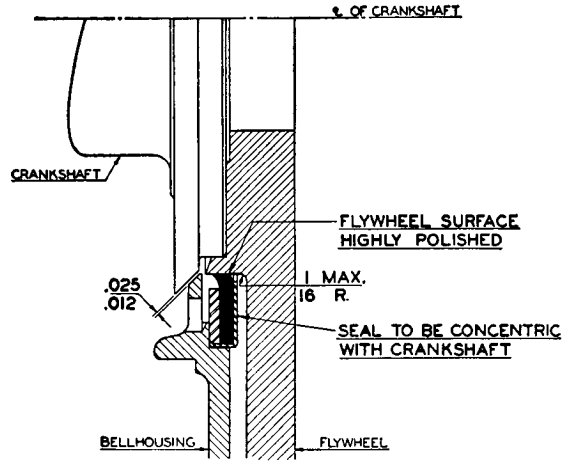

Illustration No. 9

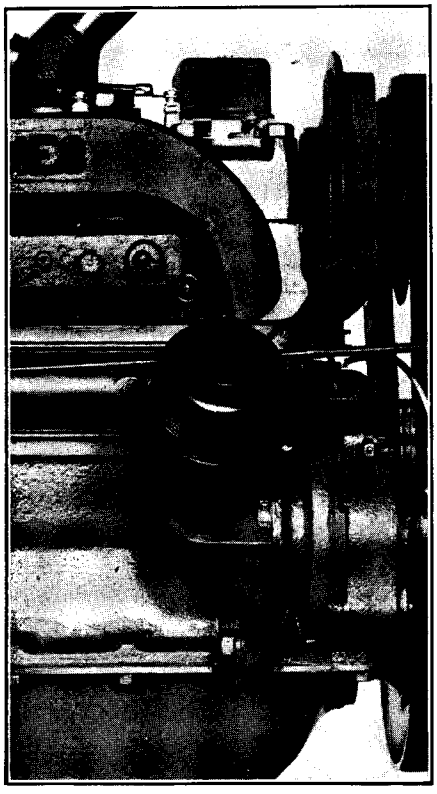

Figure No. 1

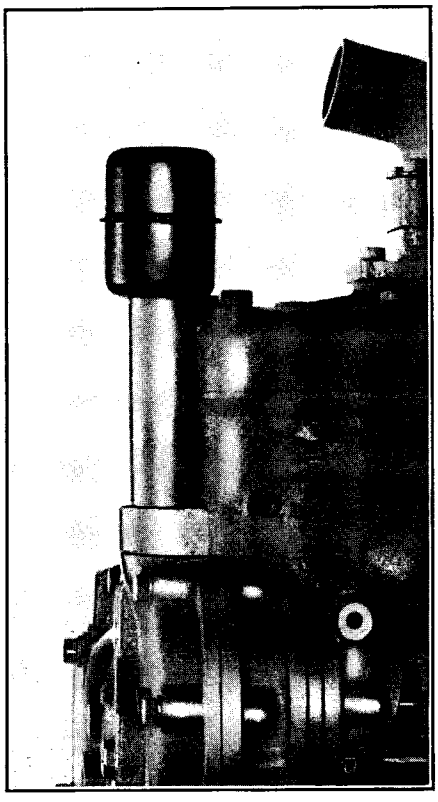

Figure No. 2

Illustration No. 10

2. Remove breather cap, see Illustration No. 10, Fig. No. 1 and 2.

3. Dip in lubricating oil. If oil bath type, fill to level mark on breather body.

CAMSHAFT

The camshaft is supported on four large diameter bearings in the crankcase; these bearings are removable and can be renewed. It is driven by means of a suitable gear which meshes with the crankshaft gear. The timing of these two gears requires no check of position of the valve. It is only necessary to line up the punch marks on the two gears, the cam gear being shown as A and the crank gear as B in Illustration No. 11.

TO REMOVE CAMSHAFT FROM ENGINE

1. Remove oil pan. See Page 47.
2. Remove oil pump. See Page 48.
3. Remove gear cover. See Page 39.
4. Remove valve tappet covers and with a valve spring compressor lift valves so that all the valve tappets may be blocked up, as shown in Illustration No. 12. A nail, if cut off as shown in the Illustration, may be used for this purpose. Lower spring compressor carefully so nail does not snap out and pinch fingers.
5. Pull the camshaft forward out of the engine. It may be necessary to turn the crankshaft slightly to permit the camshaft bearing journals to pass the crank throws.
6. The camshaft gear is pressed off to the rear of the camshaft. Place suitable support under rear of the front bearing journal and press gear back off of gear seat. The gear can then be easily removed from the camshaft.
7. Although it is seldom necessary to remove the thrust plunger from the camshaft it may be removed in the following manner. With a torch quickly heat the plunger to anneal it. Allow the plunger to cool then drill through the plunger with a 5/16" diameter drill and tap the hole with a 3/8"-16 tap. Using a 3/8" cap screw of suitable length the plunger may be pulled from the shaft.
8. If new camshaft bearings are needed, drive out old bearings with driver (13564-A). See Illustration No. 13. The same driver may be used to drive in the new bearings. See Illustration No. 14.

TO REASSEMBLE THE CAMSHAFT

1. Insert Woodruff key in shaft.
2. Press camshaft into gear.
3. Place a small amount of grease or heavy oil on the thrust washer and place thrust washer on gear.

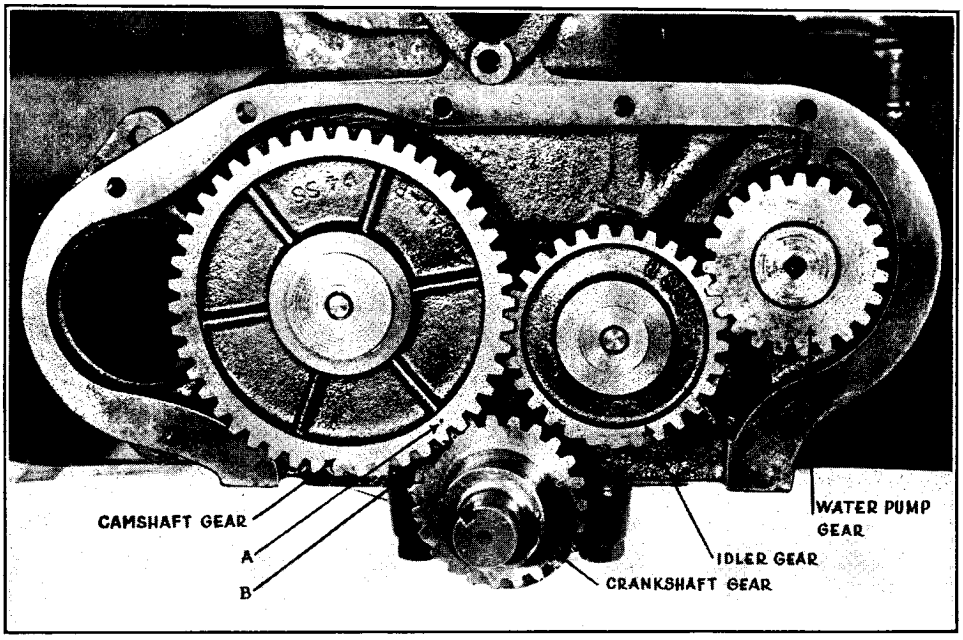

Illustration No. 11

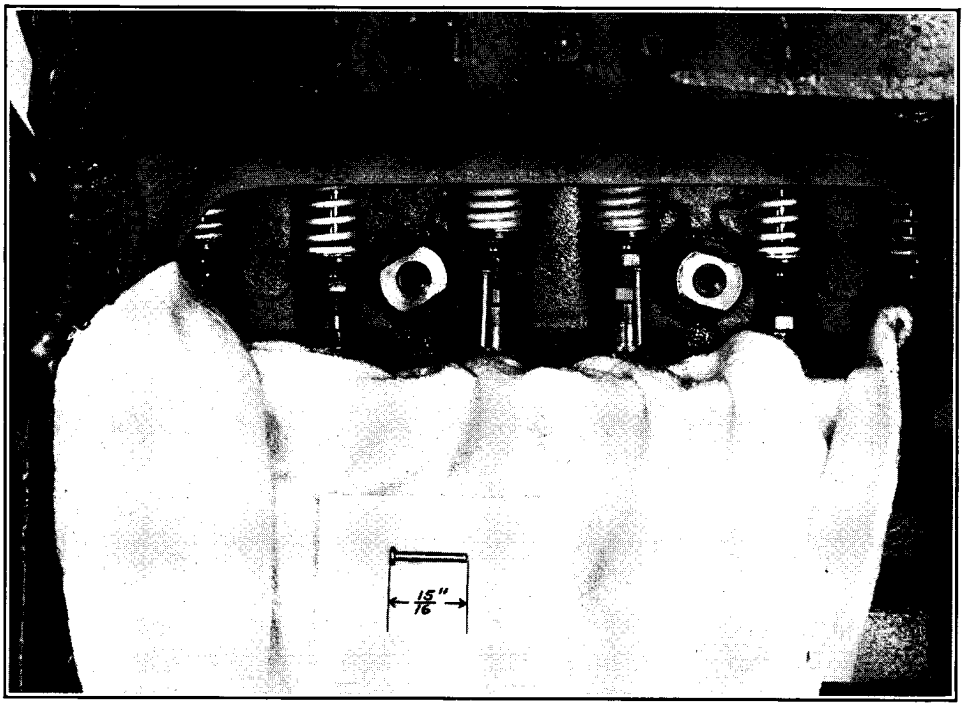

Illustration No. 12

4. If thrust plug has been removed, press in new plug. Do not damage thrust washer.
5. Drive new bearings into place with driver (13564-A). See Illustration No. 14. These bearings are cut to allow for the press fit when the bearings are pressed into the case. Therefore, no reaming should be necessary. However, the shaft should be checked in the bearings for proper clearance of .0015″ to .0025″.
6. Use care when installing the camshaft that the cams do not damage the bearings as this usually causes tight bearings.

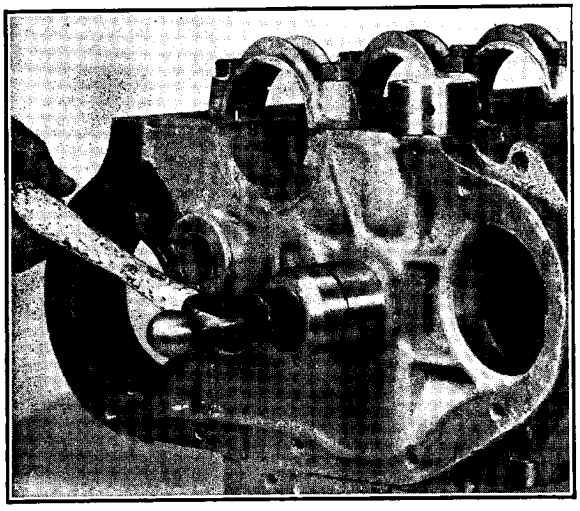

Illustration No. 13

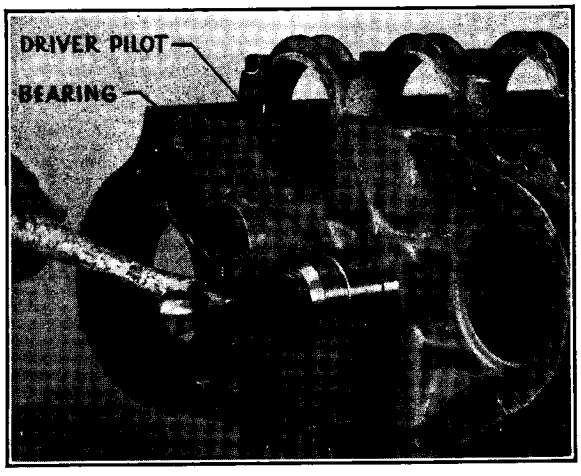

Illustration No. 14

CARBURETOR

A carburetor is an accessory designed to mix gasoline and air in proper proportions and to furnish this proportionate mixture to the engine under varying operating conditions.

It is essential to clearly recognize that the function of the carburetor cannot extend beyond the proportionate mixing of fuel and air. This knowledge will avoid many false leads in diagnosing so-called "carburetor troubles". Bear in mind the carburetor delivers the proper mixture into the manifold. The manifold carries this mixture to the cylinder. In the cylinder the mixture is compressed by the piston. While under compression, a spark from the spark plug ignites the fuel mixture. The explosion caused by igniting the fuel mixture causes the piston to travel downward in the cylinder, rotating the crankshaft, etc.

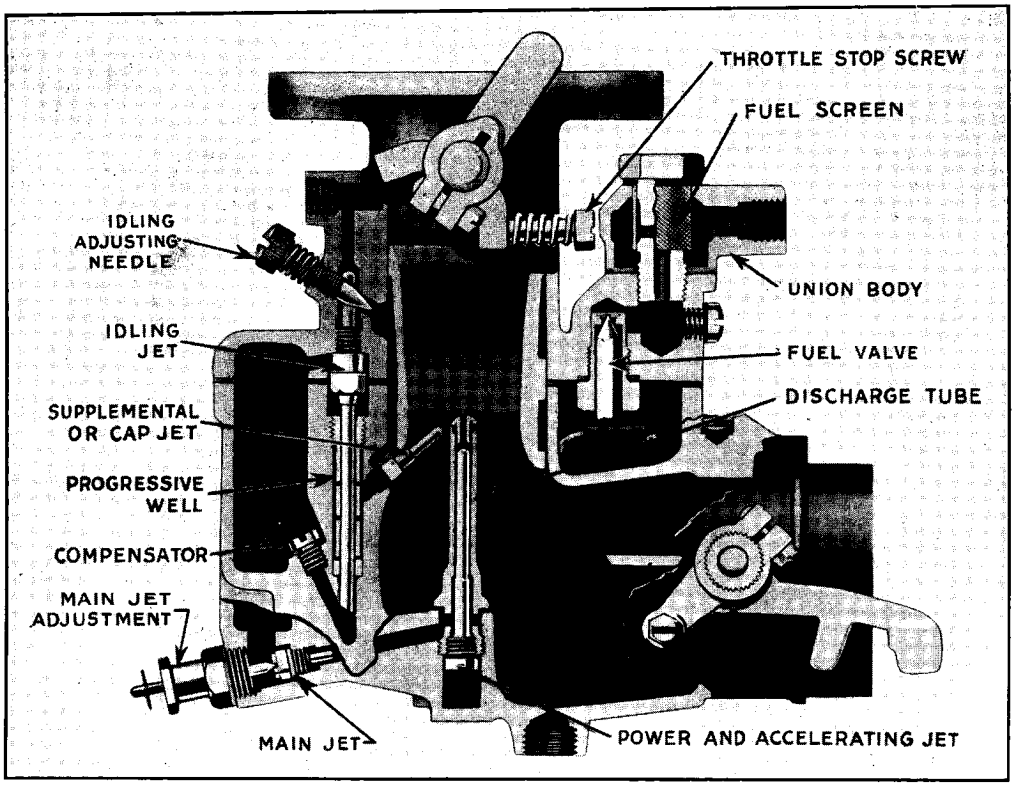

Illustration No. 15

This seems to be carrying the subject a long way from the carburetor but it is done only to point out that all of these other parts of the combustion system can affect the results obtained from the fuel and air mixture which was prepared by the carburetor.

OPERATION

The Zenith Compound Nozzle system, Illustration No. 15, of carburetion is used to illustrate this text. This consists of the Main Jet, directly connecting fuel in the bowl with the air stream through the Discharge Tube; and the Compensating Jet which flows into an open well connected with the air stream through the Supplemental Jet. The main jet flow varies with suction and delivers an increasing amount of fuel as the suction increases. The open well kills suction on the compensating jet so it flows the same under all suctions. In combination, the rich and lean jets give an average mixture of correct proportion.

Idling, acceleration and economizer action are provided by the idling and acceleration systems described in detail on the following pages.

NORMAL RUNNING: Refer to Illustration No. 15. On part throttle operation (between idling and full power) the fuel is measured by the main and compensating jets, the former being more effective at higher and the latter at lower speeds. The air is measured by the Venturi and the fuel is carried into the air stream slightly above the venturi throat from the main and compensation jets by the discharge tube and supplemental jets, respectively. These jets are of such size as to give a very lean and economical mixture.

IDLING: The idling system consists of an Idling Jet and tube to supply the fuel, an Idling Needle Valve to correct the idling mixture and a channel to carry the mixture into the carburetor barrel at the edge of the throttle. The desired idling speed is set by the stop screw on the throttle lever.

The idling system functions only while starting and idling. When the throttle is opened past the idling position the fuel goes the other way through the discharge tube and supplemental jet and the idling system is automatically out of operation.

FULL POWER AND ACCELERATION: Full power, either for top speed or hard pulling, requires a richer mixture than part throttle operation. So does acceleration. See Illustration No. 16.

This additional richness of mixture is provided by means of the accelerating and economizer system feeding through the Power and Accelerating Jet, its fuel stream merging with that of the main jet at the top of the discharge tube.

Under part throttle the suction (or vacuum) above the throttle is higher than when the throttle is open. This suction holds up the Economizer and accelerating Piston Assembly. The Check Valve is open and the Economizer Valve is closed, thus shutting off fuel from the power and accelerating jet.

When the throttle is opened the suction falls, and so does the piston. The falling piston builds up a pressure below it, which forces the check valve to its seat thus preventing the fuel from being forced back into the bowl. The piston falls on the economizer valve pushing it open, and the fuel displaced by the piston is forced out through the power jet. This is the accelerating charge.

If the throttle is held open the piston will remain at the bottom holding the economizer valve open. This allows the fuel to continue flowing through the power and accelerating jet. This jet has a measuring hole in its tip which measures only enough additional fuel to develop full power.

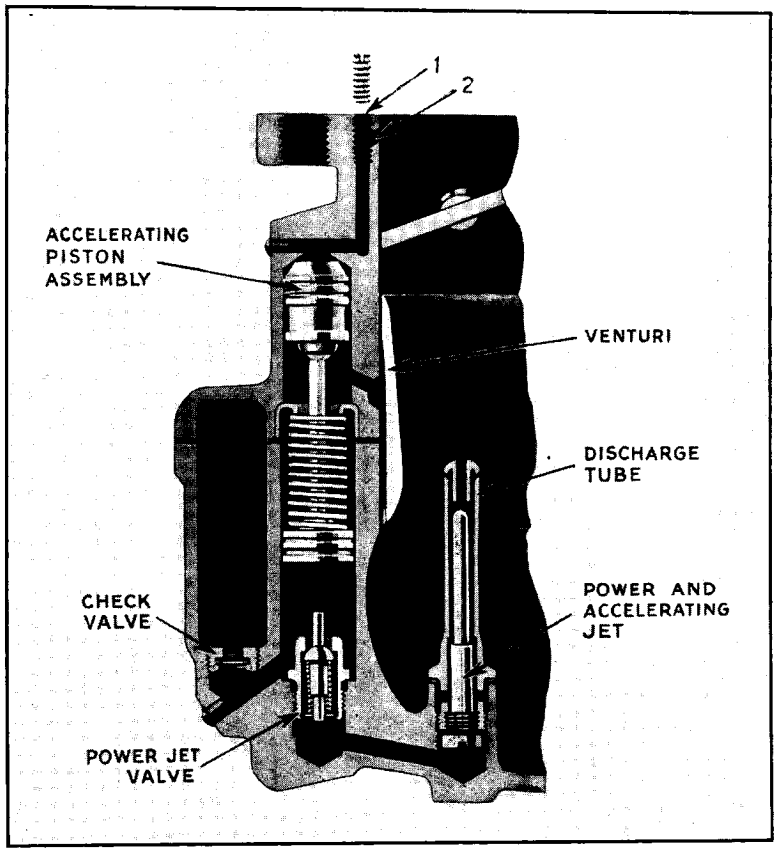

Illustration No. 16

When the throttle is partly closed the suction increases above it, the piston is drawn up to the top, the economizer valve closes and only a very economical amount of fuel can be fed to the engine.

AIR CLEANER AND AIR FILTER RESTRICTION

Most air filters, now used on gasoline engine carburetors, accumulate the dirt they separate from the incoming air. As this dirt builds up it has an action similar to closing the choke valve. Both cause restriction and this increases the suction on the carburetor jets. Very little increase in suction is sufficient to create a mixture so rich that it will not only seriously impair engine operation but will also dilute the oil and cause as much wear as dirt.

CONNECTING ROD

The connecting rods have precision or insert type bearing construction. These have the cap and rod split slightly below center so the split in the shells opposite the locking lugs do not match with the split in the forging. This type is divided into two types, one having shims on one side only, no shims being used on the side having provision for locking the shells. The second type is machined without shims. Therefore when reconditioning of bearings becomes necessary, it is accomplished by using new shells or inserts. Do not file or grind cap as new bearings cannot be installed in a rod that has been filed or ground.

NOTE: As built at the factory the connecting rods and caps are marked on the camshaft side and to the front of the engine with the cylinder number in which they are used.

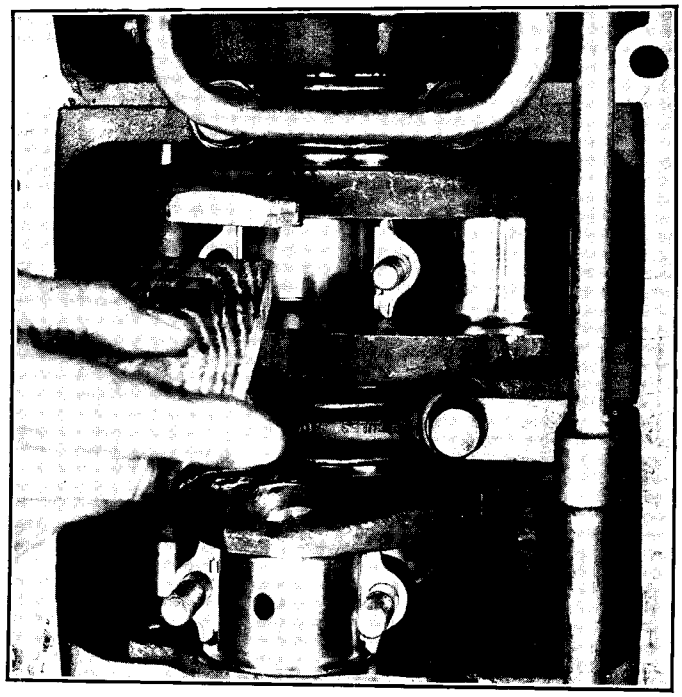

Illustration No. 17

TO REMOVE CONNECTING RODS

CAUTION: Connecting rods and caps are matched —keep these paired together as otherwise they cannot be reinstalled.

1. Remove oil pan. See Page 47.
2. Remove cylinder head. See Page 31.
3. It is not necessary to remove the oil pump, however, its removal will facilitate working on connecting rods.
4. Turn the crankshaft until the rod is in a convenient position for removal of cap, then remove cotter pins and cap nuts.
5. With a soft hammer (such as rawhide or fibre) tap the rod to loosen and remove cap.
6. With a suitable piece of wood, Illustration No. 17, push the piston and connecting rod out through the cylinder bore. Use care that the connecting rod does not scratch the cylinder wall. To insure against scratching, wrap lower part of rod with a wiping cloth.
7. Repeat the above operations for each connecting rod or a quicker method is to remove the two rod caps that are down at the same time.

TO REPLACE CONNECTING RODS AND PISTONS

1. Inspect the crankshaft for any rough or scored marks that might damage the new bearings. If any rough spots are found, use an oil stone, very fine emery cloth or Crocus cloth to polish the shaft. Clean shaft thoroughly after polishing.
2. Select the proper piston and connecting rod assembly and turn the crankshaft so that it is in correct position.
3. With the piston rings compressed as shown in Illustration No. 18, use a hammer handle or block of wood to force the piston and rings into the cylinder bore. At the same time use care that the connecting rod is in line with the crankshaft journal.
4. With the piston entirely in cylinder bore, insert upper shell and pull connecting rod down to crankshaft.

5. Place a ¼" x ½" x .0015" piece of feeler stock in the cap. Place the lower shell in the cap and assemble the cap to the connecting rod. Tighten the cap screws to proper tension and try the connecting rod for side movement. The connecting rod should move sideways with a firm pressure of the hands. After obtaining the proper movement of the rod in the above manner, remove the piece of feeler stock and reassemble the connecting rod cap. Tighten the screws as before and again try the side movement of the rod. It should move easily.
6. Assemble the cap to the connecting rod. Draw up the cap to proper tension. See chart on Page 62. If no torque wrench is available this tension would require a tight pull on a 10" wrench. Illustration No. 19 shows use of torque tension wrench.
7. Repeat the above operations for all connecting rods.
8. Install cotter pins.

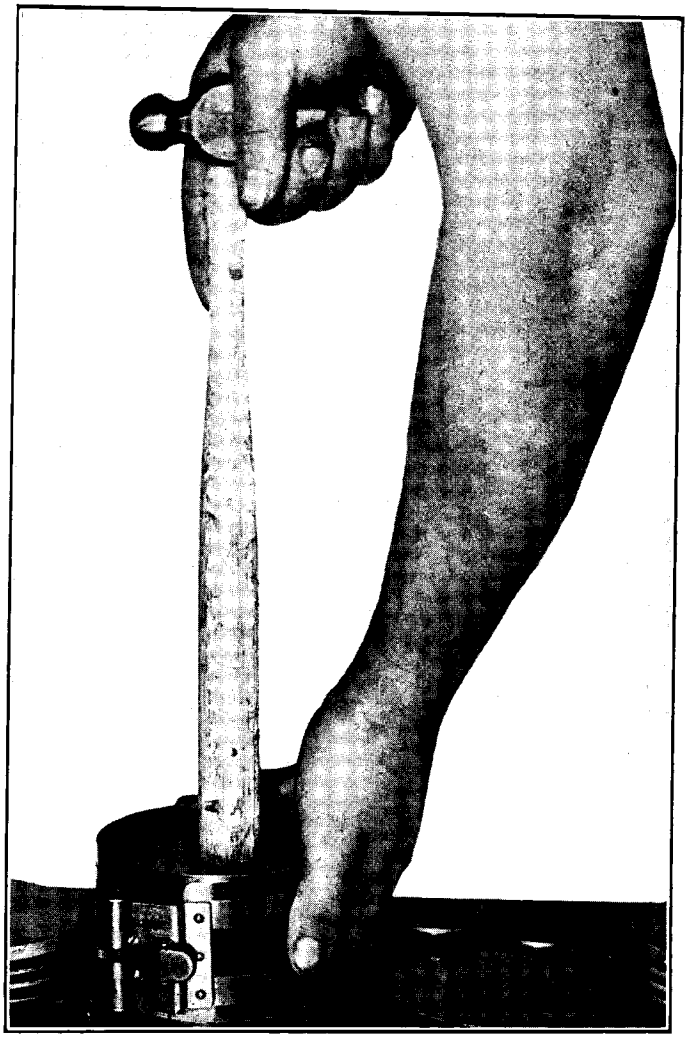

Illustration No. 18

CONNECTING ROD BEARING REPLACEMENT

If excessive clearance develops between shaft and bearing shells, new bearing shells should be installed. If the clearance is excessive with the new bearings, regrind the shaft and use undersize bearings.

The connecting rods may be replaced as outlined below.

1. Remove oil pan. See Page 47.
2. Locate crankshaft so connecting rod cap can be removed.
3. Remove cotter pins and nuts and remove cap screws.
4. With a soft hammer, tap the cap to loosen it and remove the cap.
5. Replace bearing shells as outlined under 4, 5, 6, 7 and 8 above.
6. Reassemble oil pan to engine. See Page 47.

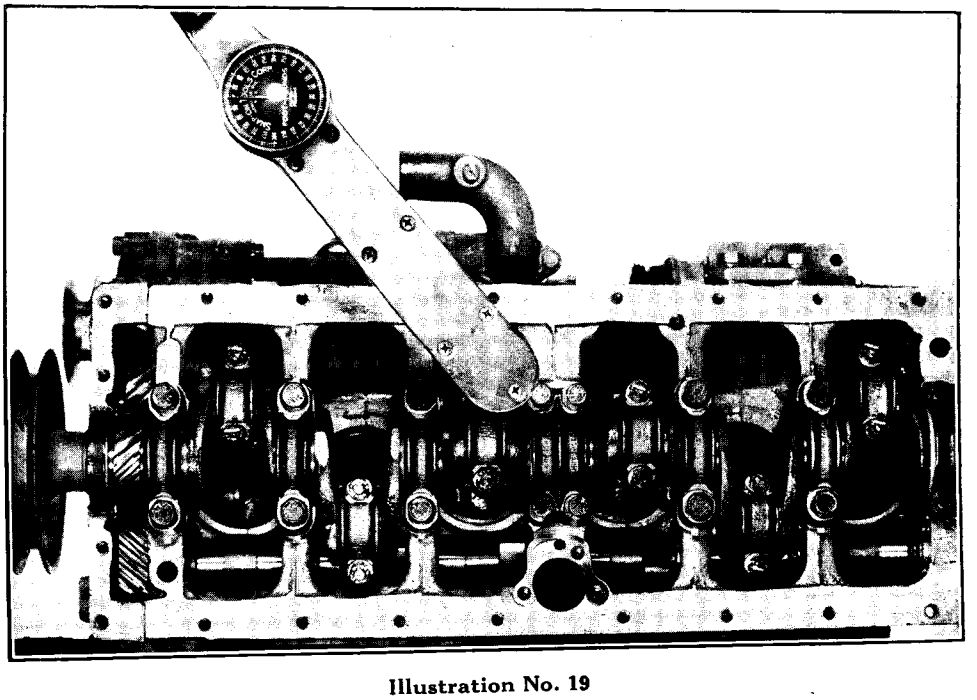

Illustration No. 19

COOLING SYSTEM

Perhaps the best method for care of the cooling system is to clean and flush the system periodically, also use some good rust and corrosion preventive between cleaning periods. Almost all natural water contains some mineral salts which stimulate corrosion.

Exhaust gas leakage between cylinder head and gasket also results in corrosion since exhaust gases discharge into the water, combining to form a variety of acids such as carbonic, nitrous and sulphurous acids, all supporting electrolytic corrosion. It is therefore important that the cylinder head screws be drawn down at regular and frequent intervals to prevent exhaust gases from leaking into the water jacket, by retightening these screws every 30 days or 2000 miles.

Air leaks around the hose connections and through the water pump should be carefully guarded against, since oxygen is a major factor in promoting corrosion. Check the hose connections frequently for air leaks.

If the engine or unit is equipped with a pressure type sealed system, it is imperative that the correct type radiator cap be used. This is determined by the type of system used.

There are two types of sealed cooling systems which are used extensively. One type has a safety relief valve arrangement built into the radiator filler cap, Illustration No. 20. The overflow pipe is also connected to the radiator filler neck above the lower seat of the pressure cap. In this manner, if excessive pressure develops in the cooling system, the lower part of the pressure cap will raise from its seat and allow the vapor to escape through the overflow pipe.

This type cap should never be removed quickly. Always turn the cap off slowly until the pressure has escaped through the overflow pipe, then remove the cap.

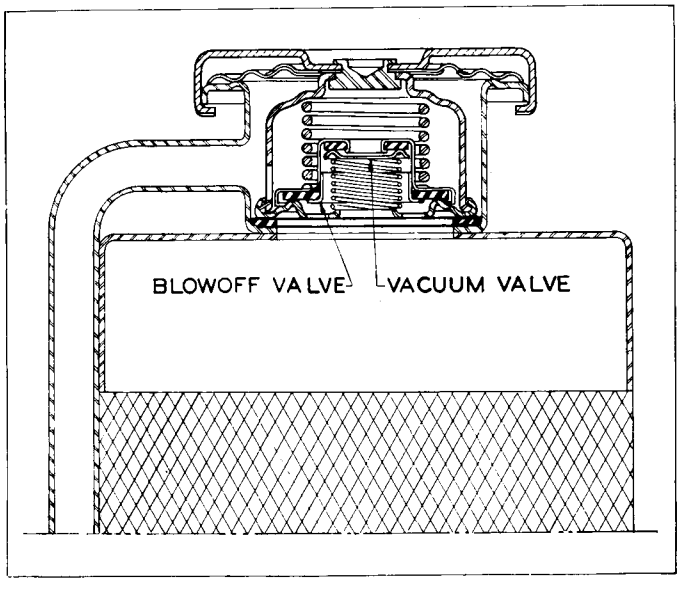

Illustration No. 20

The second type of pressure sealed cooling system has the pressure relief valve and overflow pipe built into the top tank as a separate unit. (Not connected to the filler neck).

However, if any type of sealed cooling system is used, the proper filler cap, good gaskets and a smooth gasket surface is essential if excessive loss of coolant is to be prevented.

From the above it can readily be understood why serious overheating of the engine results when the incorrect filler cap, bad gaskets or a rough surface is encountered.

Use a good commercial neutralizer in the cooling system—one purchased from reputable companies, to obtain best results follow instructions of the manufacturer.

CRANKSHAFT

The crankshaft is a machined forging having all bearing journals surface-hardened. The nominal diameter of the main bearings is 2½" while the nominal diameter of the connecting rod journals is 2". The shaft has passages drilled to carry oil under pressure to the connecting rod bearings. These passages should be cleaned with wire brush, see Illustration No. 21, before shaft is installed in engine.

While the diameters given above are only nominal, the following table gives actual sizes, both standard and undersize, to which the shaft may be reground.

Size	Main	Connecting Rod
Standard	2.498/2.497″	1.988/1.987″
.020″ U. S.	2.478/2.477″	1.968/1.967″
.040″ U. S.	2.458/2.457″	1.948/1.947″
.060″ U. S.	2.438/2.437″	1.928/1.927″

To replace crankshaft main bearings, see Page 44. To replace crankshaft connecting rod bearings, see Page 28.

TO REMOVE CRANKSHAFT GEAR

If a suitable arbor press is not available the following method may be used. Due to the extremely tight fit of the crankshaft gear on the crankshaft, it is almost impossible to pull this gear with any of the commercial pullers. Since replacement of this gear would only be brought about by the gear being badly worn or damaged, it may be removed in the following manner. Using a ¼″ diameter drill centered midway between the edge of the keyway and the base of the gear teeth, drill through the gear parallel with the keyway, then spread the gear with a chisel and pull from shaft.

CAUTION: Be careful not to drill into the crankshaft.

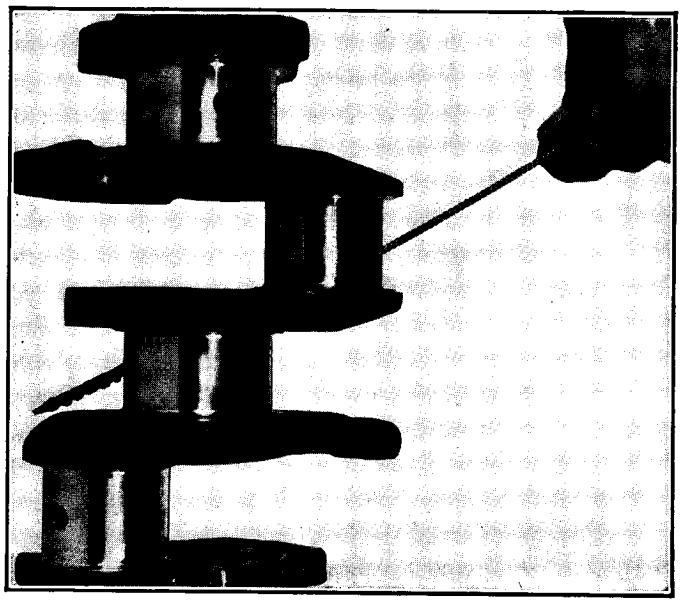

Illustration No. 21

TO INSTALL NEW GEAR

1. Insert the Woodruff key in the shaft.
2. Lay the gear on a sheet of asbestos or other fireproof material and heat the gear with a blow torch evenly on both sides until the gear turns a pale straw yellow. (If the gear is clean and untarnished, this color will indicate it is heated to approximately 450°F.)
3. Assemble the hot gear on the crankshaft and with a suitable driver quickly force the gear into correct position. A piece of 2″ diameter pipe may be used as a driver.
4. Allow the gear and shaft to cool.

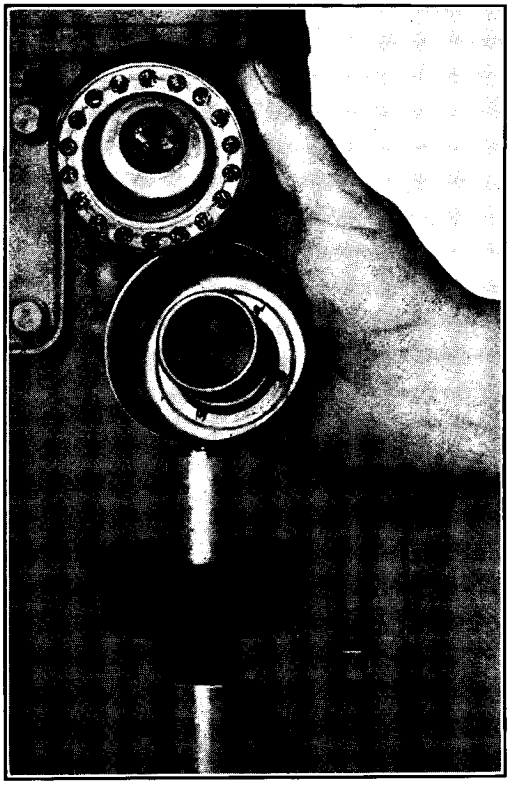

Illustration No. 22

CRANKCASE VENTILATION

Crankcase ventilation is to create a flow of clean air through the crankcase of the engine to help carry off the corrosive gases which are the byproducts of combustion and which leak by the pistons and valve stems.

This system consists of an oil bath type breather, Illustration No. 22, mounted on the left hand or water pump side of the engine, and a metering valve mounted in the intake manifold and connected through suitable tubes to the rear valve or tappet cover plate, Illustration No. 23. The metering valve consists of three major parts, see Illustration No. 24. The two halves of the body, one which forms the connection into the intake manifold and the other which allows the attaching of the ventilation tubes from the crankcase, these two pieces forming a body in which the weighted metering pin works. On some engines one or two of these valves are mounted in the intake manifold and the function of these is to meter the amount of air which will flow through the crankcase while the engine is running at either full load or part load. In order that the carburetion is not upset at idling speeds, the increased vacuum offsets the gravity pull of the weighted metering pin, moving it to its uppermost position and thus cutting down the amount of air which it will bypass into the intake manifold.

Periodic cleaning of these parts will keep them functioning properly.

To clean the breather assembly, refer to Page 22.

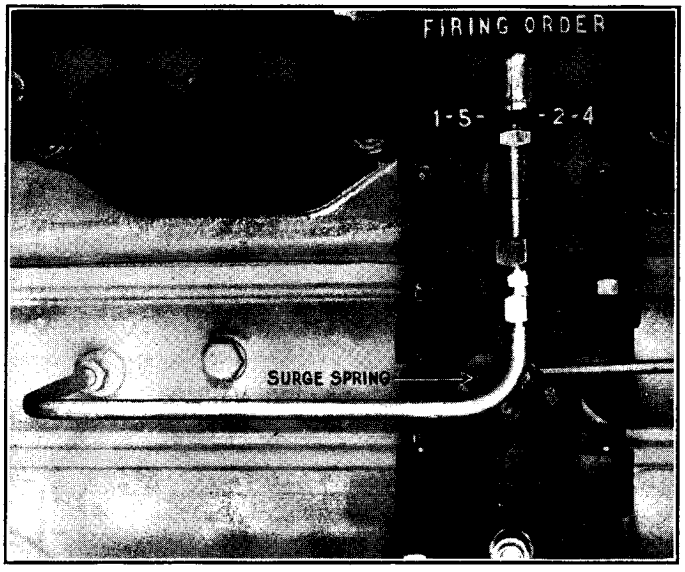

Illustration No. 23

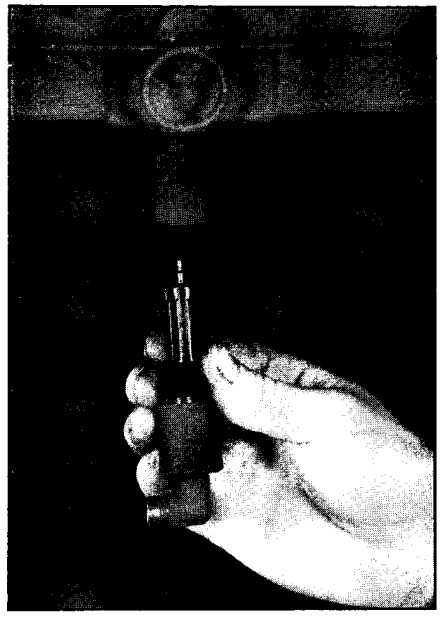

Illustration No. 24

To clean the metering valve, remove the ventilation tubes and take the valve apart and wash it in gasoline or kerosene and before assembling put a small quantity of very light oil on the valve itself to prevent sticking until its own lubrication is established. See Illustration No. 24.

The ventilation tube and rear valve cover should also be cleaned at the same time, particularly if any noticeable amount of sludge accumulation is found.

CYLINDER AND CRANKCASE

The cylinders are cast integral with the crankcase and have the water jacket carried the full length of the cylinders and also around the intake and exhaust valve seats. This results in uniform cooling of the piston and cylinder wall and has a very definite bearing upon maintenance of lower oil temperatures than is possible with any other type of construction without use of oil cooler.

Material is cast iron with forged bearing caps fastened to the crankcase with ½" and 7/16" cap screws. The most casual inspection of the cylinder block will disclose the very rigid construction provided to support the crankshaft and this rigidity coupled with the large diameter of the crankshaft results in a very rugged and smooth running engine.

The cylinders may be rebored up to .060" oversize.

For reconditioning valve seats and to replace valve guides, refer to valve grinding, Page 55.

To replace main bearings, see Page 44.

Core openings are closed by brass or steel expansion plugs. If any of these should leak, remove and replace with new plugs.

CYLINDER HEAD

The cast iron cylinder head is the conventional "L" type and is detachable. The head is attached to the cylinder block with twenty-four ½" cap screws and a steel or copper asbestos gasket.

TO REMOVE CYLINDER HEAD

1. Drain cooling system.
2. Remove water outlet pipe and hose.
3. Remove cables and bracket assembly.
4. Remove spark plugs.
5. Loosen and remove cylinder head cap screws.
6. Lift off cylinder head. Tap head lightly with a soft hammer if necessary to loosen it, but do not pry on contact surface.

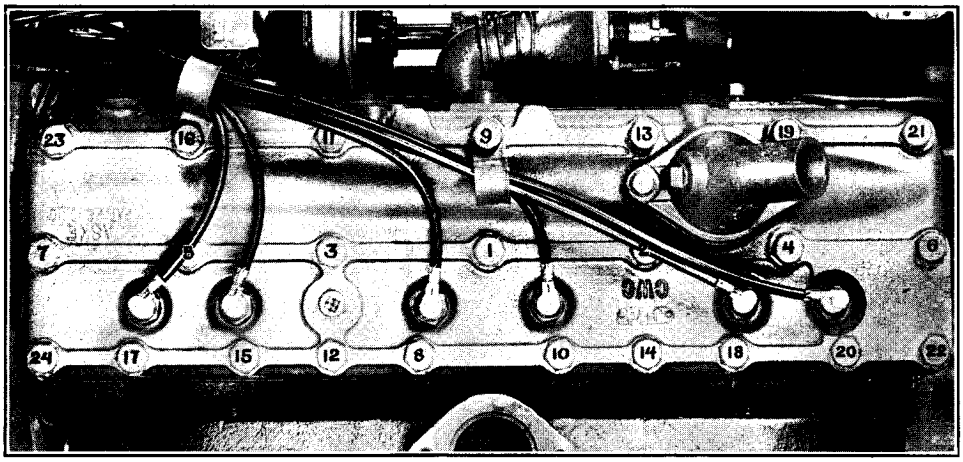

Illustration No. 25

TO REPLACE CYLINDER HEAD

1. Before reinstalling cylinder head, clean out carbon deposits by scraping or brushing.
2. Clean cylinder block and cylinder head contact surfaces.
3. Clean cap screw holes in cylinder block. Rust or dirt in these holes may prevent the cylinder head being properly drawn down, even though the correct tension is applied to the cap screws.
4. Clean the cylinder head gasket and place on cylinder block. No shellac or gasket cement is necessary. Put gasket on with bead down.
5. Assemble cylinder head on the block.
6. Assemble the cable bracket, cables, etc., that are attached by the cylinder head cap screws.
7. Start head cap screws and tighten evenly, starting at the center of the head and working progressively to the outer ends, following numerical sequence, Illustration No. 25, repeating until tight. See tension chart, Page 62.
8. Install spark plugs, be sure each has a clean gasket on it and tighten in head. Connect cables to correct spark plug.
9. Install water outlet pipe and hose (use new gasket and hose if necessary.)

FAN ASSEMBLY (COOLING)

The cooling fan mounted on the front of the cylinder block is driven from a pulley mounted on the crankshaft by the use of "vee" belts. Various types of fans, drive pulleys, vacuum pumps, air compressors or generators may be driven from the fan belts. Therefore, it is not possible to list fan belt specifications.

The fan has a self contained lubrication system which should be checked frequently. See Illustration No. 26. The lubrication system may vary with different types of fans, but all types should receive systematic care.

FAN LUBRICATION

The fan is lubricated at assembly with a sodium soap grease, of the following specifications:

Soda Soap	11-12%
Oil	86-88%
Oil Viscosity @ 100°	140-160
Trade Standard No. 1½	(Consistency)
Dropping	300°

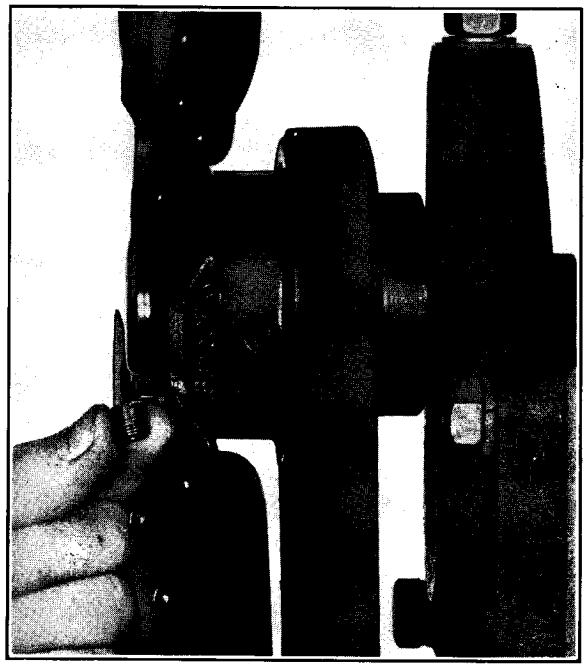

Illustration No. 26

similar to Standard Oil Company of Indiana, Oneida Grease, of high enough melting point so that the oil is fed to the bearings very sparingly. There is enough lubricant in the fan, when it leaves the factory, to last for 1,000 hours or 25,000 miles of operation. To add lubricant to the fan remove the pipe plug in the fan hub, Illustration No. 26, add the lubrication and replace the plug.

CAUTION: If a grease fitting is installed in the fan hub when greasing the fan, be sure to remove the fitting and assemble pipe plug in the opening as centrifugal force may throw the grease out through the grease fitting or the weight of the grease fitting may so unbalance the fan that the shaft will break.

FLYWHEEL

The various flywheels used on the "QX" series engines are usually made of cast iron and may be machined to accomodate different types and sizes of clutches as well as generator and other types of couplings. The flywheel is fastened to the crankshaft with four bolts and two dowels. There is also a smaller dowel used to locate the flywheel on the crankshaft for timing purposes, Illustration No. 7. The timing mark which indicates that No. 1 and No. 6 pistons are on top center may be seen through a drilled hole provided in the bellhousing, Illustration No. 27.

NOTE: The location of the timing hole may vary with different installations.

TO REMOVE FLYWHEEL

1. Remove starting motor.
2. Assuming that the clutch has been removed, remove the cotter pins and nuts from the flywheel bolts.
3. Remove flywheel with the aid of a Lady-foot pry bar as shown in Illustration 28.
4. Inspect the flywheel and ring gear for damage.
5. If necessary to remove damaged ring gear, note position of chamfer on gear teeth, so new gear can be correctly installed.
6. The ring gear may be driven from the flywheel by use of a large drift and heavy hammer. When installing the new ring gear, the gear should be heated to, but not over 450°F and then assembled to the flywheel. The ring gear must be assembled so that it is square and properly seated on the flywheel.

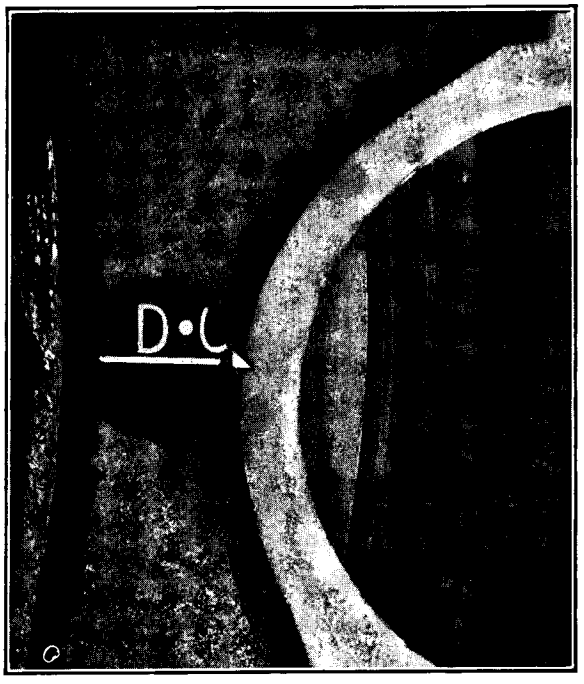

Illustration No. 27

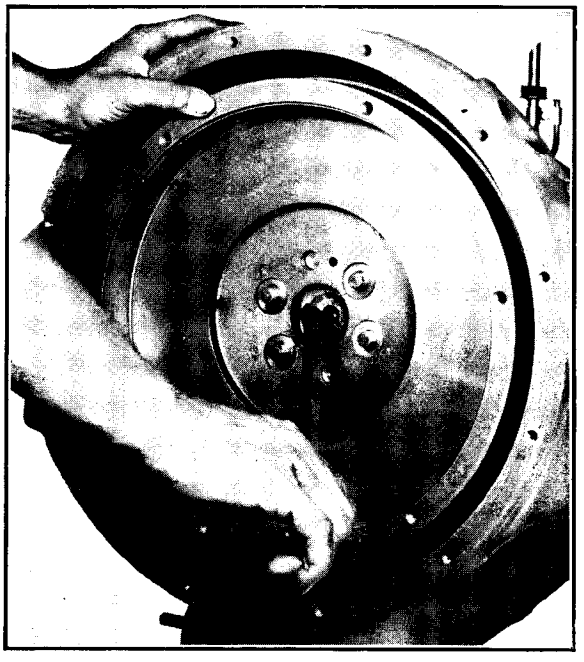

Illustration No. 28

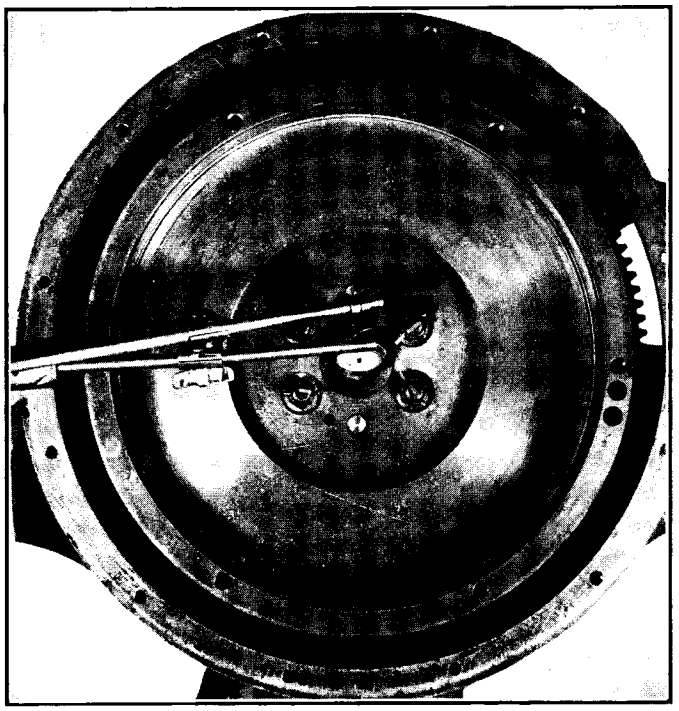

Illustration No. 29

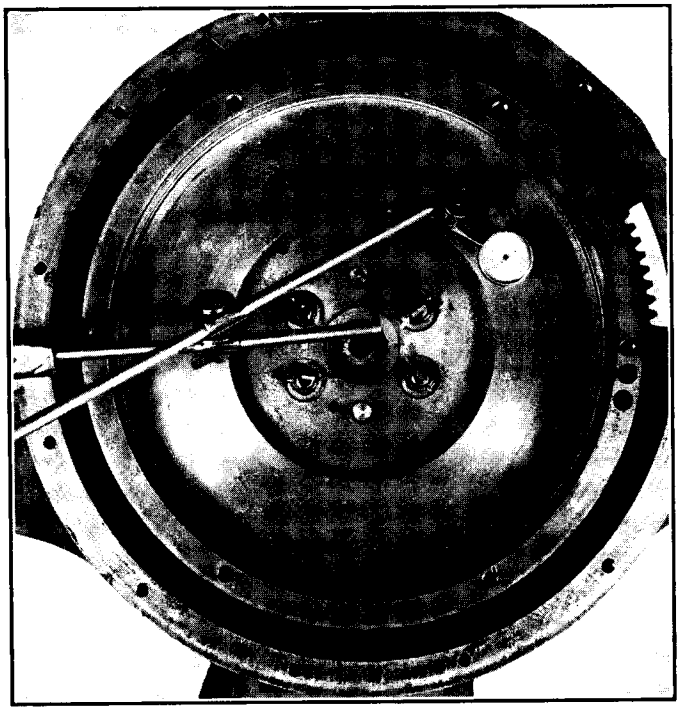

Illustration No. 30

TO INSTALL THE FLYWHEEL

1. Assemble the new seal in bellhousing. See Page 22. Illustration No. 8.
2. Polish oil seal contact surface of flywheel. This surface must not be scratched, nicked or otherwise damaged.
3. Turn flywheel so locating dowel hole is in line with the locating dowel in the crankshaft. See Illustration No. 7.
4. Install the flywheel on the crankshaft, (use care that the flywheel timing or locating dowel is properly located in relation to timing dowel hole in the flywheel) and draw into place with the flywheel attaching nuts. Do not draw any one nut down tight until all are progressively tightened.
5. Insert dowels and expansion plugs.
6. Attach indicator as shown in Illustration No. 29 to check concentricity of pilot bore. This should not exceed .005″ total reading.
7. Place indicator in position shown in Illustration No. 30 to check face of flywheel. This should not exceed .005″ total.
8. Install cotter pins.

FUEL PUMP

There are many different types of fuel pumps used on the "QX" series engines, but a careful study of the following illustrations and text will be of assistance if repairs are necessary.

The fuel pump described is of the diaphragm type operated through suitable linkages by a rocker arm actuated from an eccentric on the camshaft. It is mounted at the rear of the crankcase below the manifold. Illustration No. 31 shows sectional view of pump with nomenclature of various parts.

Since in the great majority of cases trouble attributed to the fuel pump is generally caused by failure in some other part of the fuel system, therefore, be sure that the trouble is actually in the fuel pump before disassembling and repairing it. For instance, if the engine is not getting enough gasoline, check the level of the fuel in the tank, check for broken, leaking or clogged fuel supply lines. Then before removing fuel pump from engine, check for leaking bowl gasket, loose diaphragm, top cover screws, or bad valves and springs, see Illustration No. 31.

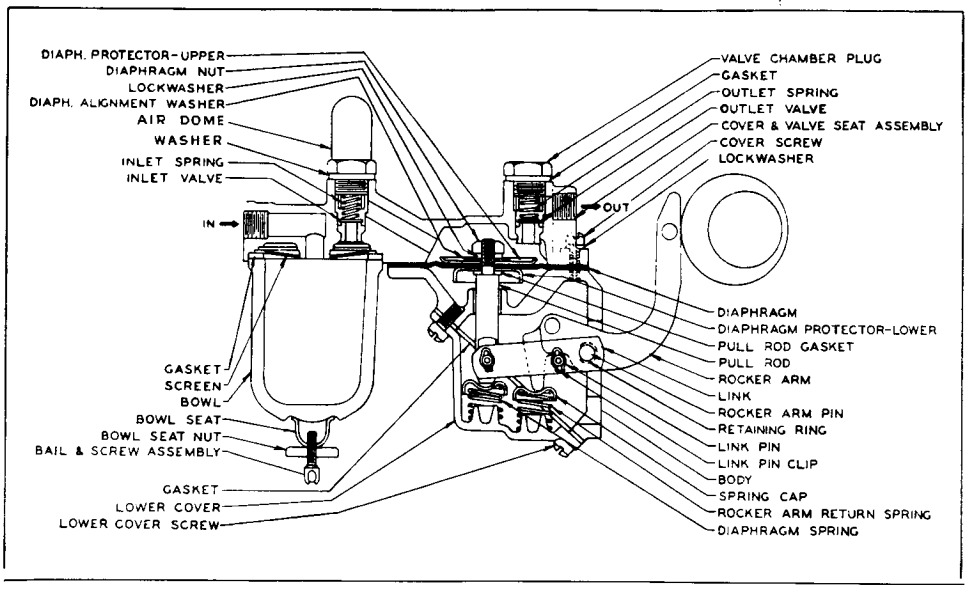

Illustration No. 31

If engine is getting too much gas, this is usually caused by defective choke arrangement, punctured carburetor float, defective carburetor needle valve or improper carburetor adjustment; this is generally not caused by the fuel pump.

REMOVING FUEL PUMP FROM ENGINE

1. Disconnect fuel line from tank and the fuel line to the carburetor and move out of the way.
2. Remove two attaching screws which hold the pump to crankcase and remove pump from crankcase, remembering that the rocker arm will catch on the case unless it is carefully pulled out of the small opening.

NOTE:—If the fuel pump is forced away from the crankcase by the spring tension on the rocker arm this will indicate that the high point of the eccentric is toward the pump and in order to facilitate installation of the pump, the engine should be cranked over one full turn to place this high spot away from the fuel pump, opposite to that shown in Illustration No. 31.

DISASSEMBLING AND INSPECTING

1. Loosen thumb nut and remove bowl.
2. Remove bowl gasket and strainer.
3. Remove check valves. These will be found under hexagon nut and air dome. See Illustration No. 32.
4. Put a mark with a chisel or file on top cover and body so pump can be reassembled in same position. See Illustration No. 38.
5. Remove top cover screws. At this point the top cover is completely disassembled.
6. Remove diaphragm from pull rod by taking off nut and diaphragm protector.
7. Remove three screws holding bottom cover, being careful not to lose springs and spring seats.
8. Remove rocker pin. This will allow pull rod, linkage and rocker arm to be removed.
9. Remove link pin from linkage to pull rod.
10. Inspect all parts carefully, discarding those which must be replaced. Parts with holes worn out of round and worn pins should be replaced as these cause lost motion in the actuating parts.

ASSEMBLING FUEL PUMP

A. Assembling The Top Cover

1. Thoroughly rinse the fine mesh wire screen in gasoline or a good commercial solvent. Dry it, being careful not to bend the screen.
2. Turn the top cover upside down. Put the screen into the bowl recess.

Illustration No. 32

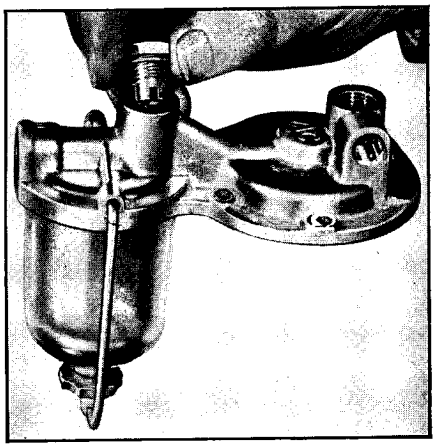

Illustration No. 33

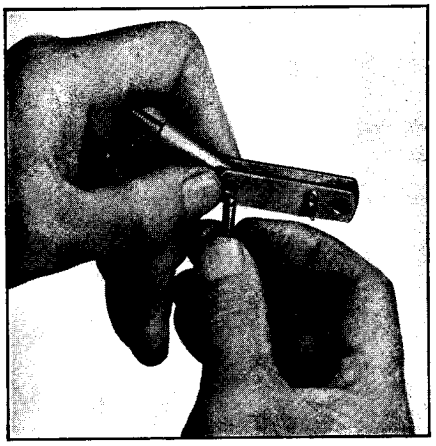

Illustration No. 34

3. Place a new bowl gasket in position.
4. Thoroughly clean the bowl. Be sure that no lint is left in it. Then put the bowl in place over the gasket.
5. Swing the bail (wire loop) over the bowl. Tighten the bowl seat nut securely with your fingers. Be sure the bowl seat has not fallen off.
6. Turn the top cover right-side-up. Put a drop of light oil such as Finol (or equivalent) on a new inlet valve, then place valve in the well or recess over bowl. Be sure it lies flat. See Illustration No. 32.
7. Place a new inlet valve coil spring on top of the inlet valve.

NOTE:—If the brass valve seats are worn or damaged, new ones can be installed. Special tools are required and can be secured from manufacturer.

8. Replace the inlet valve chamber plug and gasket, starting it with your fingers to be sure the valve spring fits up into the pocket in the plug. See Illustration No. 33.
9. Put a drop of Finol (or equivalent) on a new valve and place valve in the well or recess nearest the "outlet" opening.
10. Drop a new outlet valve coil spring down on top of the valve.
11. Replace the outlet valve chamber plug and gasket, in the same way you replaced the other plug.

NOTE:—When air dome is used, it is always placed over the outlet valve.

12. The top cover is now assembled.

B. Assembling The Body

13. Assemble the two links with one link pin and clips.
14. Attach the two links to the pull rod, with one link pin and clips. See Illustration No. 34.

WARNING!—Notice that one corner of each link is cut off. This indicates the corner which should be nearest the diaphragm, when the links are attached to the pull rod. The pull rod slips between the links.

15. Install this assembly in the pump body, pushing the pull rod up through the hole provided for it.

NOTE:—Be sure that the two links will swing to one side toward the rocker arm pin hole. This is necessary so that the rocker arm pin will pass through the holes at the ends of the links.

16. Hold the pull rod in position, and slip the rocker arm through the slot. Be sure that it slides in between the two links and that the projecting hook on it goes OVER the link pin.
17. Insert rocker arm pin through the holes in pump body (accessible from outside the pump body). See that the pin goes through one link, then the rocker arm, then another link.

18. Peen the edges of the pin hole over both ends of the pin with a pointed punch and hammer. If the rocker arm pin is of the kind which uses rings to hold it, slip the two spring rings into the grooves at each end of the pin. If the pin has a head on one end and a tapered, hollow end on the other, install a washer over the taper and spread the hollow part to retain in position.

19. Install the parts of the diaphragm assembly over the threaded end of the pull rod in the following order (See Illustration No. 35):

    Small pull rod gasket (use new one).

    Lower diaphragm protector.

    Fabric diaphragm (use a new one, and be sure that the "tab" is in a position which will not interfere with the bowl).

    Diaphragm should be dipped in kerosene to soften. It also acts as a lubricant between the layers of the cloth in the diaphragm.

    Upper diaphragm protector.
    Diaphragm alignment washer (six-sided, very thin).
    Lockwasher.
    Diaphragm nut.

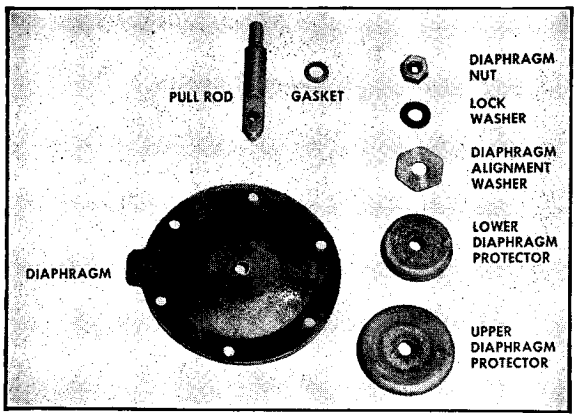

Illustration No. 35

20. Tighten diaphragm nut with open end wrench. Be sure that holes in diaphragm line up with holes in flange.
The body is now assembled.

C. Assembling Lower Cover and Attaching To Body

21. Holding lower cover in your hand, set the rocker arm spring and diaphragm spring in place over the two bosses (hollow cones) on the inside of the cover. See Illustration No. 36.

22. Put the two dished spring caps over the ends of the springs, rims down. See Illustration No. 36.

23. Place gasket on cover flange, Illustration No. 36.

24. Holding the pump body over this lower cover with your other hand, bring them together. See Illustration No. 37.

NOTE:—Be sure that the cup of one cap fits around the end of the pull rod and the cup of the other fits around the end of the rocker arm.

25. Install cover screws and lockwashers in holes provided, and tighten securely.

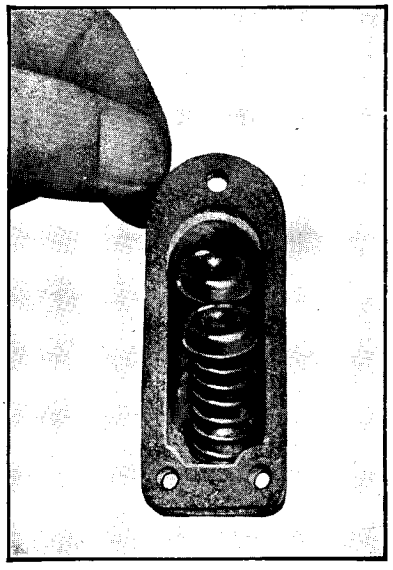

Illustration No. 36

D. Attaching Top Cover To Body

26. Put the body in a vise. Line up the scratches on the edge of the body with the scratch on the edge of the top cover. See Illustration No. 38.

27. Get the diaphragm level by moving the rocker arm. Hold it while you put in at least two opposite screws and washers finger tight. Release rocker arm and install balance of screws and lockwashers. Be sure that they pass through the holes in the diaphragm easily without chewing the fabric. Tighten these screws only enough so that they just touch the lockwashers. See Illustration No. 38.

28. Actuate the rocker arm several strokes, releasing with a snap.

29. Tighten the cover screws. Do this alternately—first, a screw on one side, then a screw on the opposite side. Tighten all screws securely. The most important single item in the repair of fuel pumps is the proper flexing of the diphragm when the cover is assembled to the body.

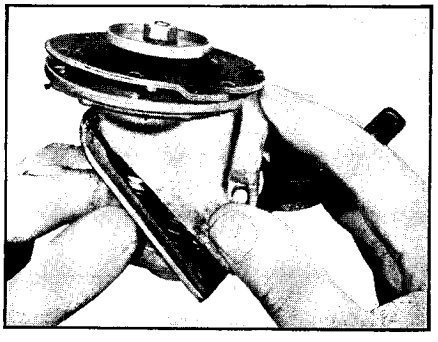

Illustration No. 37

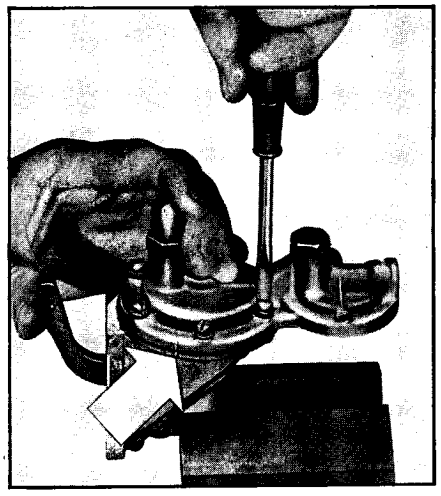

Illustration No. 38

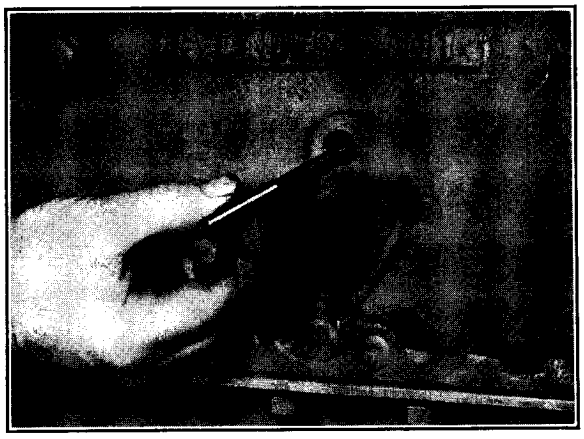

Illustration No. 39

TO TEST FUEL PUMP

Before installing fuel pump it is always desirable to test it. This can be accomplished as follows:

1. Hook the fuel supply line from the tank to the pump inlet connection.
2. Holding the pump in hand, work rocker arm using long, even strokes. After quite a few strokes the bowl will fill with fuel and after it is filled a few more strokes will force it through the pump and out the outlet side.
3. With strokes approximately ¼" to ½" at the tip of the rocker arm, the pump should be able to deliver quite a bit of fuel. If it does not with these short strokes this would indicate that the diaphragm was not correctly installed or that some of the valves were sticking.
4. Disassemble and recheck.

INSTALLING FUEL PUMP

1. Place new gasket on fuel pump and if gasket cement is available, cement the gasket to the pump body and allow to dry.
2. Insert the rocker arm in hole in crankcase, being careful to keep the flange of the fuel pump in correct position while the two cap screws are started (some installations use studs and nuts).
3. A slight pressure will be exerted by the rocker arm springs while the screws are being pulled tight. However, if this pressure is excessive, remove pump and turn engine over one turn and endeavor to install the pump as outlined above. This light pressure can be noted but it should not be so excessively strong as to tend to bend the rocker arm or prevent installation.

FUEL PUMP DRIVE PIN

Some engines have the fuel pump mounted on the side of the engine opposite the manifold and require a drive pin, Illustration No. 39, which extends across the cylinder block to the camshaft.

When installing a fuel pump on one of these engines use care that the fuel pump rocker arm is correctly positioned on the pin as breakage may result if the pump is drawn up tight while the tip of the rocker arm is under the drive pin rather than on the end of it.

Some engines have pin with head on end next to camshaft, to replace it is necessary to remove camshaft.

Caution: on engines with straight pins (not headed) do not rotate engine with fuel pump removed as pistons may be damaged.

GEAR COVER

The gear cover used on this engine is usually cast iron and covers the gear train at the front of the engine.

The governor and front support are mounted on the gear cover. The camshaft, idler shaft and water pump end thrust is controlled by suitable adjusting screws assembled in the gear cover.

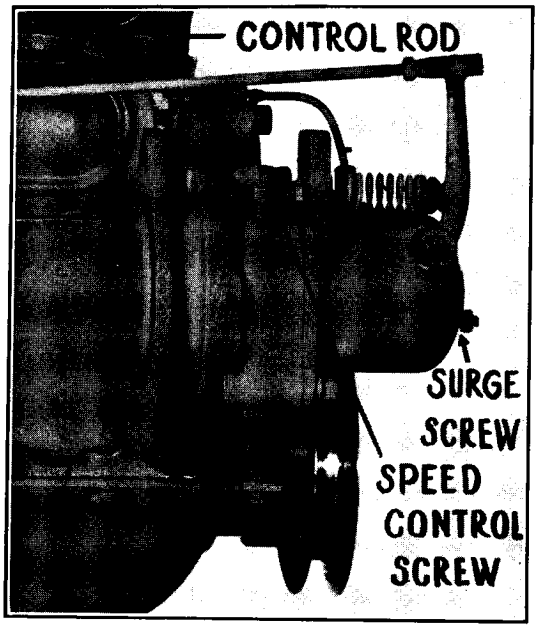

Illustration No. 40

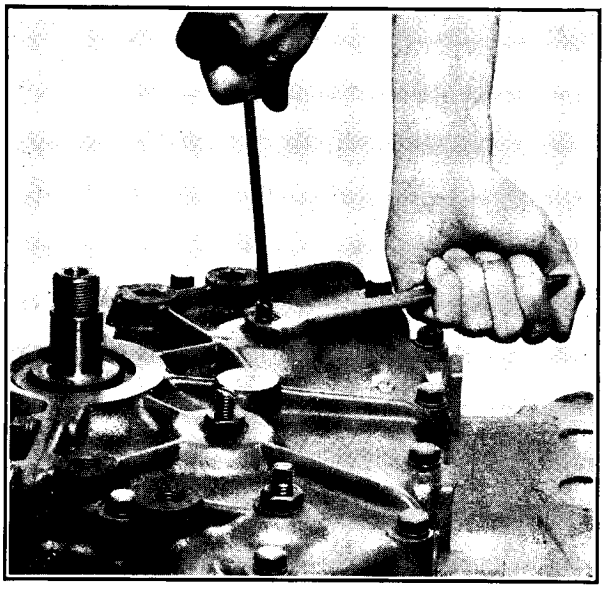

Illustration No. 41

TO REMOVE THE GEAR COVER

1. Assuming that the radiator has been removed, disconnect governor to carburetor control rod hooked to governor lever, Illustration No. 40.
2. Remove governor attaching screws and lift governor away from gear cover.
3. Remove starting crank grab and fan drive pulley.
4. Remove front motor support screws. If necessary to raise front of motor to release the front support, use a large block of wood under front of oil pan so jack will not damage it. The front support may be removed from the gear cover if necessary.
5. Remove gear cover attaching screws and pull gear cover forward away from the engine. The crankshaft oil seal will pull off the shaft with the gear cover. If no gasket or seals are available, use care when removing these parts.

TO ASSEMBLE GEAR COVER TO THE ENGINE

1. Wash and clean the gear cover and fasten a new gasket to the gear cover with gasket cement. Loosen thrust screw lock nuts and back screws out two or three turns.
2. Carefully install the oil seal on the crankshaft and slide the seal about one inch back on the shaft. If available, use new seal and ring.
3. Assemble the gear cover on the seal. Use care that the seal properly seats in the groove provided for it in the gear cover.
4. In order to avoid any difficulty with the oil seal sleeve when pushing the gear cover back in place loosen the oil pan and allow the front end of the oil pan to drop $\frac{1}{8}$" to $\frac{1}{4}$". Then push the gear cover back into place, (To do this, relocate jack supporting engine.)
5. Check to see that oil seal sleeve is properly located in the oil pan.
6. Start the gear cover attaching screws and with some tension on the lockwashers of the gear cover to cylinder block screws, tighten the oil pan screws, also the oil pan to gear cover screws. After these are tight, draw up the gear cover screws. Keep seal concentric with crankshaft.
7. Assemble front motor support.
8. Assemble fan drive pulley and starting crank grab.
9. Assemble governor to gear cover and fasten in place with cap screws.
10. Connect governor to carburetor control rod.
11. Adjust camshaft, idler shaft and water pump thrust screws. To adjust these screws, loosen the lock nut and turn the screw until it contacts the thrust plugs in their respective shafts, then turn the screw out approximately $\frac{1}{8}$th turn and tighten the locknut. See Illustration No. 41.

GENERATOR

A periodic inspection should be made of the charging circuit. The intervals between these checks will vary depending upon the type of service. Dirt, dust and high speed operation are factors which contribute to increased wear of the bearings, brushes et cetera. Under normal conditions an inspection of the generator should be made every 100 hours.

1. **Wiring**—A visual inspection should be made of all wiring to insure that there are no broken wires and that all connections are clean and tight. Special attention should be paid to the ground connections at the battery and generator.
2. **Commutator**—If the commutator is dirty or discolored it can be cleaned by holding a piece of 00 sandpaper against it while turning the armature slowly. Blow the sand out of the generator after cleaning the commutator. If the commutator is rough or worn the generator should be removed from the engine, the armature removed and the commutator turned down.
3. **Brushes**—The brushes should slide freely in their holders. If the brushes are oil soaked or if they are worn to less then one-half of their original length they should be replaced.
4. **Lubrication**—Add 3 to 5 drops of medium engine oil to the oilers in the end heads every 100 hours of operation.

If the generator does not function properly after the above checks, the generator and the regulator or circuit breaker should be taken to an authorized service station for inspection and repairs

GOVERNOR

Some engines are equipped with a governor for speed regulation which is mounted on the gear cover and is driven by a gear meshing with the camshaft gear.

This governor operates on the principle of centrifugal weights or "flyballs". In operation the force developed by the revolving weights is opposed or balanced by a spring called the operating spring. The spring is of the correct length and of the proper tension to control the engine speed at certain specified speeds with FULL LOAD.

CAUTION—On maximum speed. The governor is set for the maximum engine speed at the factory and should require no further adjustment. However, if necessary the governed speed may be changed, within certain limits, by turning the screw (Illustration No. 40) in to increase or out to decrease the speed. Do not set governor for a higher speed than that specified for a particular application.

If governor surges, (sometimes called "hunting"), it may be necessary to make some slight adjustments. First make sure that spark plugs are clean and working properly and that carburetor jets are clean, also the carburetor throttle rod and all connections or joints on the governor rod work freely without binding and at the same time have no lost motion.

The length of the rod connecting the governor lever to the valve box lever is also important. The length of this rod should be such that with the engine at rest the valve box throttle should be wide open. The position of the surge spring, Illustration No. 40 should be such that it is compressed about 1/16" when the lever is pushed all the way to the closed position. However, it may be necessary, if the engine still surges, to loosen lock nut and turn surge screw out several turns. Then slowly screw it back until surging stops and then tighten lock nut.

If necessary to inspect or repair the governor it can readily be removed for this purpose. Disconnect governor control rod and lubricating oil line then remove the governor attaching screws and lift governor away from the engine.

TO DISASSEMBLE THE GOVERNOR

The following reference letters are found in Illustration No. 42 (unless otherwise noted).

1. Loosen governor operating spring adjusting screw KS and remove the spring KC and pilots KR and LI.
2. Remove screws JU and lockwashers JV then remove body assembly JT from base assembly KS.
3. Remove fork riser bearing JY from shaft LM.

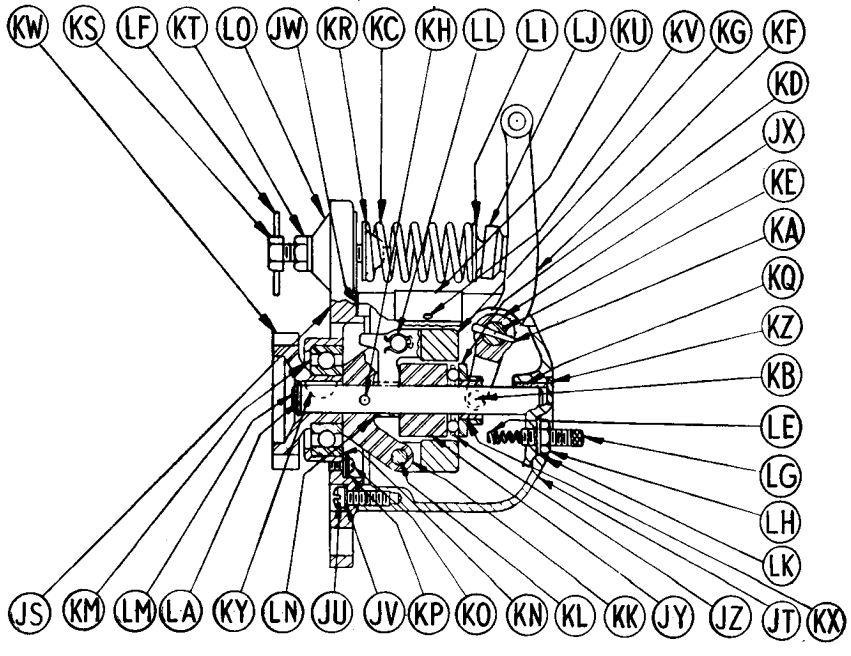

Illustration No. 42

4. Remove snap ring LA and pull gear KW from shaft LM then remove Woodruff key KY.
5. Remove bearing retaining screws KO, lockwashers KP and plain washers KN then pull shaft and weights from base.
6. Remove weight pin clips LL, weight pins KL, and weights KG. (The weights are similar.)
7. Remove taper pin KH from weight carrier KK then with suitable support under weight carrier KK press shaft LM out of weight carrier. (These parts should be serviced as an assembly, therefore, this paragraph may be disregarded.)
8. Press shaft LM out of bearing KM.
9. Remove small expansion type plug from body and with a small pin punch inserted through this hole remove fork pin KA.
10. Pull shaft KE and lever KF from body as an assembly. (CAUTION: be careful of the twelve roller bearings LB, Illustration No. 43, which may fall out when this shaft is removed).
11. Remove packing retainer LC, packing LD, bearing retainer LC, roller bearings LB and inner bearing retainer LC, Illustration No. 43.
12. Remove bumper spring screw nut LH, screw LG, gasket LK and spring LE.
13. To remove bushing KQ remove expansion plug KZ and press out bushing.
14. Clean all parts and inspect for wear or damage.

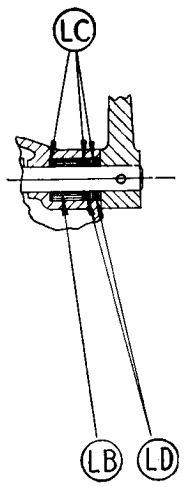

Illustration No. 43

TO REASSEMBLE THE GOVERNOR

1. Press bushing KQ into body KX and install expansion plug KZ.
2. Place bearing retainer LC, Illustration No. 43, in control shaft hole and insert roller bearings LB, outer bearing retainer LC, packing LD, packing retainer LC and insert control shaft KE, Illustration No. 42, while holding fork in position so that shaft KE may enter it. Be sure fork bumper spring arm is on the correct side. (Light cup grease applied to the roller bearings will hold them in place until the control shaft is installed.)
3. Install fork taper pin KA and small expansion plug.
4. Press shaft LM into bearing KM.
5. Press weight carrier KK on to shaft LM and insert taper pin KH.
6. Assemble weights KG, insert weight pins KK and lock with pin clips LL.
7. Assemble shaft and weight assembly in base plate JS and install bearing retainer screws KO, lockwashers KP and plain washers KN.
8. Insert Woodruff Key KY and with suitable support under shaft press on gear KW and install snap ring LA.
9. Place fork riser bearing JY on shaft LM with the large end toward the weights.
10. Place new gasket JN on base and assemble to body with screws JY and lockwashers JV.
11. Assemble operating spring pilot KR on adjusting screws KS.
12. Place pilot LI on spring KC and assemble spring and pilot to governor.

IDLER GEAR

QX-5 SERIES ONLY

The idler gear is supported on a shaft which in turn is supported in a bushing pressed into the cylinder block. The shaft is pressure lubricated from passages drilled from the main oil passage. The shaft and gear are also drilled in such a manner that twice each revolution of the idler gear a spurt of oil is forced into a groove in the rear side of the idler gear. This oil is thrown by centrifugal force through small holes drilled from the groove to the outer circumference of the gear. By this method the timing gears are assured ample lubrication. See Illustration No. 44.

TO REMOVE THE IDLER GEAR AND BUSHING

1. Remove gear cover. See Page 39.
2. Pull idler gear and shaft forward out of crankcase.
3. Press shaft out of gear.
4. The bushing may be removed by using a puller (6624-A) as shown in Illustration No. 45.

TO INSTALL NEW GEAR AND BUSHING

1. Install new bushing. Note position of hole in bushing. Use extreme care that the oil hole in the bushing is in line with the hole in crankcase. (13232-A driver is used to install the bushing, see Illustration No. 46).
2. These bushings are usually reamed to size. However, try the shaft in the bushing; it should have .0075″ to .001″ clearance.
3. Insert Woodruff key in the idler shaft and press the shaft into the gear.

4. Apply a small amount of grease to the thrust washer. This will tend to hold the thrust washer onto the gear hub while the gear shaft is being installed in the engine.
5. Start the shaft in the bushing, line up teeth so that they mesh with the cam and water pump gears, then press the gear into place. If camshaft or water pump gears have not been moved it will not be necessary to retime the distributor. If the gears have been moved, see Ignition Timing below.
6. Reassemble the gear cover, See Page 39.

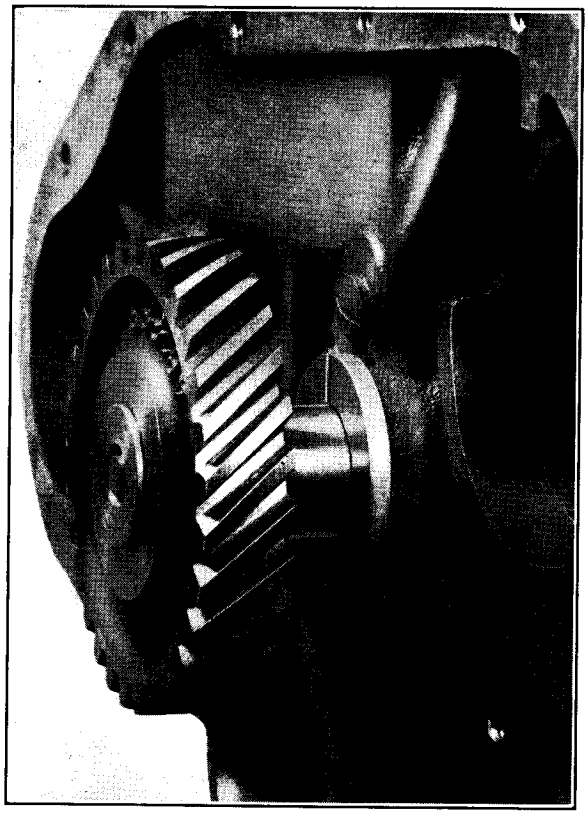

Illustration No. 44

IGNITION TIMING (Battery)

NOTE:—Since the ignition system is usually not furnished by the Hercules Motors Corporation, the following is inserted here for general information only. Instructions for ignition timing will differ slightly with different makes of electric equipment and the following is in the nature of general instructions suitable for any type of battery ignition. If the distributor has been removed or for any reason it becomes necessary to check or reset the ignition timing, proceed as follows:

There is a timing hole through the bellhousing for spotting engine, see Illustration No. 27. When the dead center mark (DC 1 and 6) on the flywheel lines up with the mark across the center of the hole in the bellhousing, the pistons for No. 1 and No. 6 are on top dead center. The first step in setting or checking the ignition timing is to locate the (DC 1 and 6) mark and line it up with the mark on the bellhousing. To determine whether the engine is in firing position for No. 1 or No. 6, the engine can be cranked with spark plugs removed to determine the compression stroke of one of these cylinders, or the valve tappet cover can be removed and the position of the valves noted. If both tappets for No. 1 cylinder are clear, indicating that the valves are closed, and exhaust valve on No. 6 is not completely closed, this will indicate firing position for No. 1 cylinder.

With the ignition points clean and making a square contact and set to the proper gap opening of .018″ to .020″, the points should be just beginning to open on dead center with retarded spark. The automatic advance or manual advance or combination of the two, whichever is employed, will then advance the spark to the proper position when the engine is running.

There are several methods of checking accurately the exact point of contact opening. One method is by using a test light which, if connected in series with primary circuit (when ignition switch is on), will be lighted when ignition contacts are closed and not lighted when contacts are open. To change ignition timing, loosen clamp screw holding spark control arm to distributor and turn distributor until correct timing is obtained and then tighten clamp screw. If distributor is being retimed after having been removed, it is now necessary to see if rotor lines up with distributor cap segment connected to No. 1 cylinder and that the remaining ones are connected in the order 1-5-3-6-2-4 which is the firing order of the standard engine. For counterclockwise engine the firing order is 1-4-2-6-3-5.

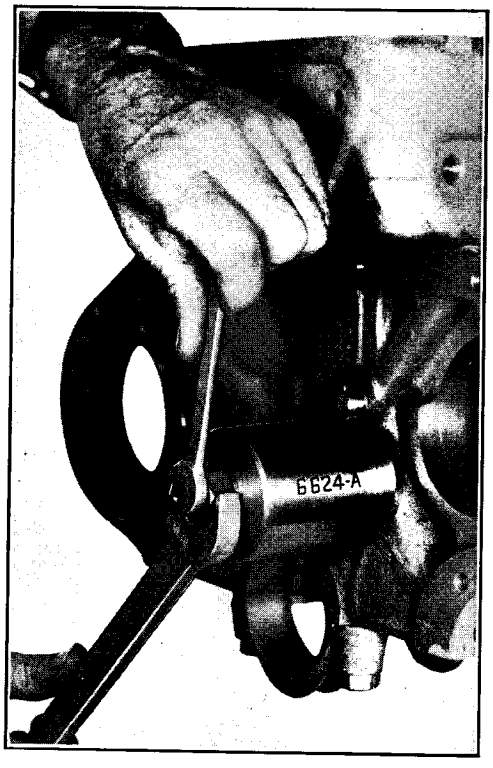

Illustration No. 45

SAVE YOUR BATTERIES

Do not turn engine with starter unnecessarily. Use hand turning crank whenever possible.

MAGNETO IGNITION TIMING

The magneto, producing an ignition spark only at certain definite points in the rotation of the magnet rotor must be connected and timed to the engine in such a manner that the spark is always available at the instant it is required in the cylinder.

If the magneto has been removed for any reason and it becomes necessary to check or reset the ignition timing, proceed as follows:

There is a timing hole through the bellhousing for spotting engine, see Illustration No. 27. When the spark mark (do not confuse with DC mark) which is before top dead center of the flywheel lines up with the mark across the center of the hole in the bellhousing, the cylinders are in firing position. The first step in setting or checking the ignition timing is to locate the spark mark and line it up with the mark on the bellhousing.

To determine whether the engine is in firing position for No. 1 or No. 6, the engine can be cranked with spark plugs removed to determine the compression stroke of one of these cylinders, or the valve tappet cover can be removed and the position of the valves noted. If both tappets for No. 1 cylinder are clear, indicating that the valves are closed, and exhaust valve on No. 6 is not completely closed, this will indicate firing position for No. 1 cylinder. (No. 1 cylinder is the one nearest to the timing gears.)

a. Rotate the impulse coupling until the line on the distributor gear is visible in the observation window. This operation is best performed by turning the impulse coupling in the opposite direction of rotation to that in which it will be driven by the engine, thus eliminating the engagement of the impulse weights. (On some magnetoes the timing marks are on the impulse coupling and coupling housing.)

b. Mesh the impulse coupling with the engine drive. Approximate timing is now obtained. Carefully align the magneto with the engine drive and securely fasten the unit in place.

c. Remove the distributor plate by loosening the four screws. This will expose the interrupter assembly.

d. To obtain the exact timing, the interrupter points must just begin to open. It may be necessary, in order to get that position, to loosen the adjustable drive member and turn the impulse coupling in a clockwise or anti-clockwise direction.

e. Reinstall the distributor plate and insert the cable between outlet No. 1 and cylinder No. 1 which is then timed to fire correctly.

Complete the installation by connecting the remaining cables of the magneto to the spark plugs in their proper firing order (marked on engine manifold). The firing sequence on the distributor or high-tension end of the magneto follows the opposite direction of rotation from that indicated by the arrow on the magneto name plate and must be taken into consideration when the cables are connected to the spark plugs.

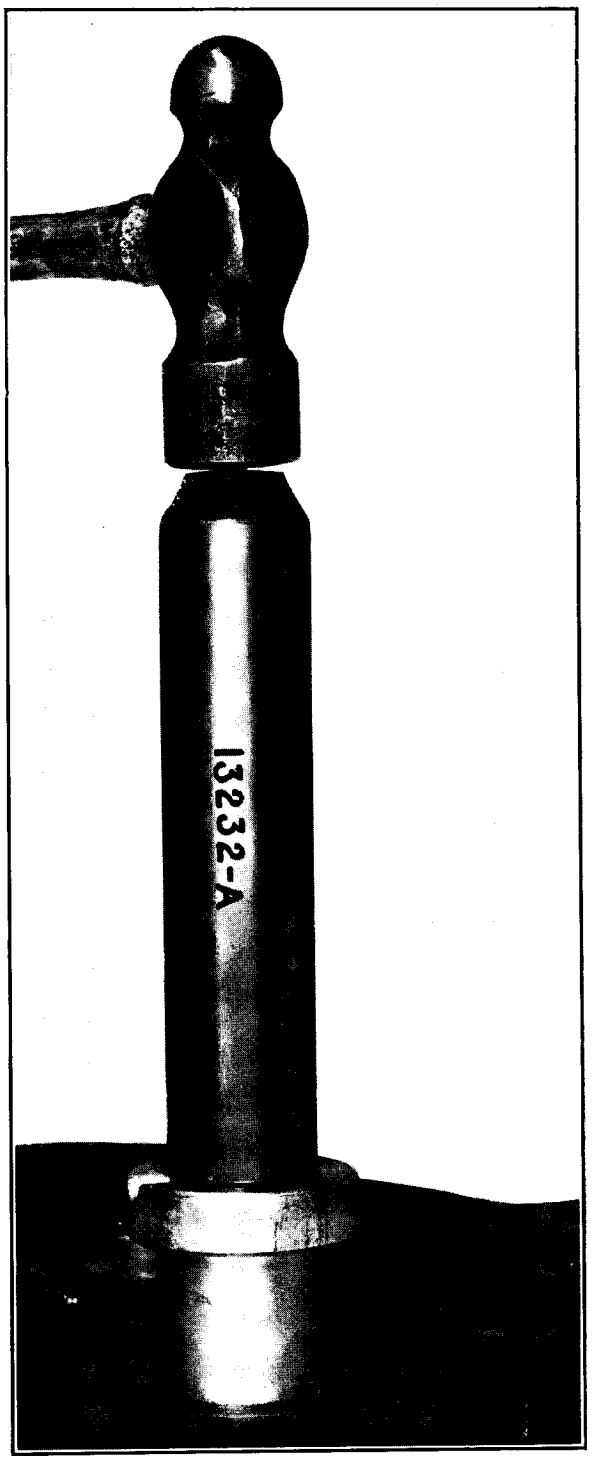

Illustration No. 46

MAIN BEARINGS

The use of seven main bearings permits a main bearing placed on each side of each connecting rod bearing. See Illustration No. 2, this construction helps to eliminate vibration at high speeds. The center and rear main bearing caps are each held in position by four alloy steel cap screws 7/16" in diameter while the remaining ones are held by two alloy steel cap screws 1/2" in diameter.

The main bearings are precision or insert type, and in this construction there is a removable shell in each cap as well as for the upper part. In this type of construction the upper shell is interchangeable with the lower shell for each bearing. The shell type is further divided into two types, one having shims for adjustment, the other has no shims and reconditioning of this type bearing is accomplished only by replacing the shells. These Precision type shells are completely finished before being put in place and no line reaming or scraping is required. This allows renewal of bearings to be easily accomplished. The Precision type shells each have a small ear or projection which fits into a recess which allows the ear to rest against the adjoining case or cap to prevent the shell from rocking or rotating. These shells are approximately 1/16" thick. The bearing metals commonly used in the Precision shell type bearings are harder and have a higher melting point than ordinary babbitt metal and this requires the use of a hardened crankshaft.

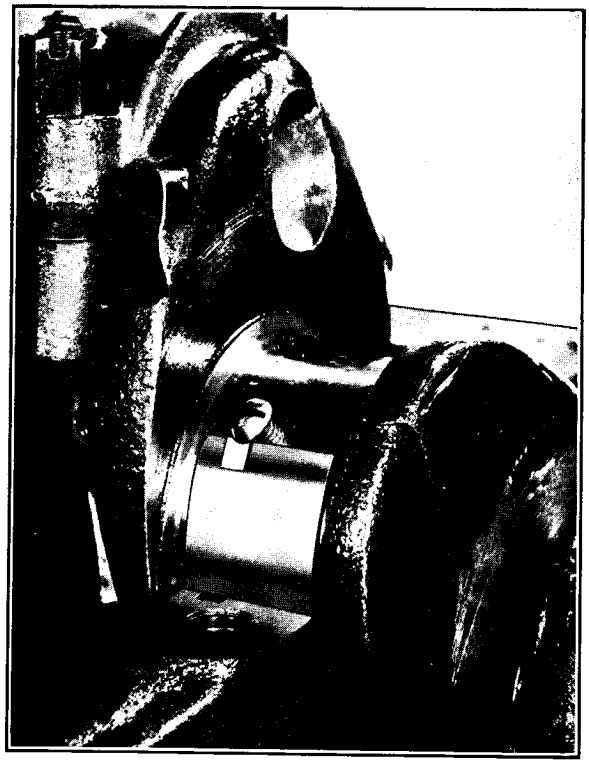

Illustration No. 47

ADJUSTMENT AND FITTING OF BEARINGS—Except Shimless Type

The bearings in these engines are readily accessible after the oil pan and oil pump are removed. The bearings are adjusted for excessive clearance, due to normal wear, by removing shims. The bearings should never be adjusted so tight that they bind or drag. A certain minimum clearance is required at all times to provide an adequate oil film between the shaft and bearing and insure a free running engine. The bearings in these engines are of ample proportion and the full pressure lubrication system employed will give long lasting bearings provided they are not adjusted too tight. The best method is to remove just enough shims from each bearing in turn until the shaft can be turned only with considerable effort, then add the proper amount of shimming to each side of bearing. See Table of Clearances, Page 62. Shim thickness corresponding to the clearance figure given in the table should be added to each side of the bearing. While testing each bearing for tightness by cranking, the spark plugs should be removed to relieve compression and the other bearings should be comparatively loose. After all bearings are adjusted and all caps tightened it should be possible to turn the shaft readily with the crank. When using trial shimming to get the proper drag on the shaft and before adding the clearance shimming, the shims can be decreased .001" by removing a .003" shim and putting in a .002" shim on each side. To increase the shimming .001" at a time remove a .002" shim and put in a .003" shim on each side.

Tightening of main bearing cap screws requires some care to prevent too much strain on the parts. Special wrenches are on the market which enables the mechanic to measure the force of his pull when tightening such parts. The wrench tension values given on Page 62 show the correct amount of pull to use on various screws. No attempt should be made to refit these bearings by filing or grinding the caps as this will ruin the cap so new shells cannot be installed.

REPLACEMENT OF MAIN BEARINGS

It is not necessary to remove the engine from the unit to replace the shell type main bearings. Unless of course, the crankshaft is damaged or worn to the extent that it must be replaced.

The following outline may be used as a guide when replacing the bearings when the engine has not been removed from unit.

1. Disconnect battery cable at battery.
2. Disconnect starter cable and wiring then remove starter.
3. Drain crankcase oil.
4. Remove oil pan.
5. Remove oil pump.
6. Loosen all main bearing cap screws.
7. Remove one bearing cap at a time and make bearing replacement. To remove the upper shell, a small pin may be inserted in the crankshaft oil hole and the shaft rotated so that the pin will push the bearing out. The new bearing may be inserted in the same manner. See Illustration No. 47.

CAUTION:—Be sure to remove the pin before assembling the bearing cap.

8. Assemble bearing cap and lower shell and tighten screws. See table on Page 62. If no torque wrench is available, use wrench with 12″ handle.
9. After installing new thrust bearings, on rear main bearing, check end thrust, Illustration No. 48 (see table, Page 62.) It is permissible to draw file the thrust bearings to obtain the proper clearance if necessary.
10. Thoroughly recheck inside of engine for loose screws, nuts, et cetera.
11. Install oil pan.
12. Install starter.
13. Connect starter cables.
14. Connect battery cable.
15. Fill crankcase to 4/4 mark on bayonet gauge, See Illustration No. 4, with proper grade of oil.
16. Start engine and immediately check oil pressure. (some slight adjustment may be necessary). See Page 49.

If sufficient, allow engine to run for a few minutes while checking for oil leaks, etc., then stop the engine and recheck the oil level. Add oil if necessary.

MANIFOLD (Intake and Exhaust)

There are a great many different types of manifolds used on the QX and QXL series engines, therefore, it is not practical to discuss these at length in this book. Manifolds differ as to the size of carburetor attaching flanges and size of intake gallery. Also the intake manifold ports vary in size. Different exhaust outlets are used on different installations. Different manifolds are also manufactured for use with different types of fuel. From this list of differences one can readily see the importance of replacing the manifold on the engine with the same type manifold unless the engine is to be applied to a different type of operation.

In installing manifolds it is essential to use new gaskets and to be sure that the manifold intake and exhaust ports line up and are the same size as those in the cylinder block. When tightening the mani-

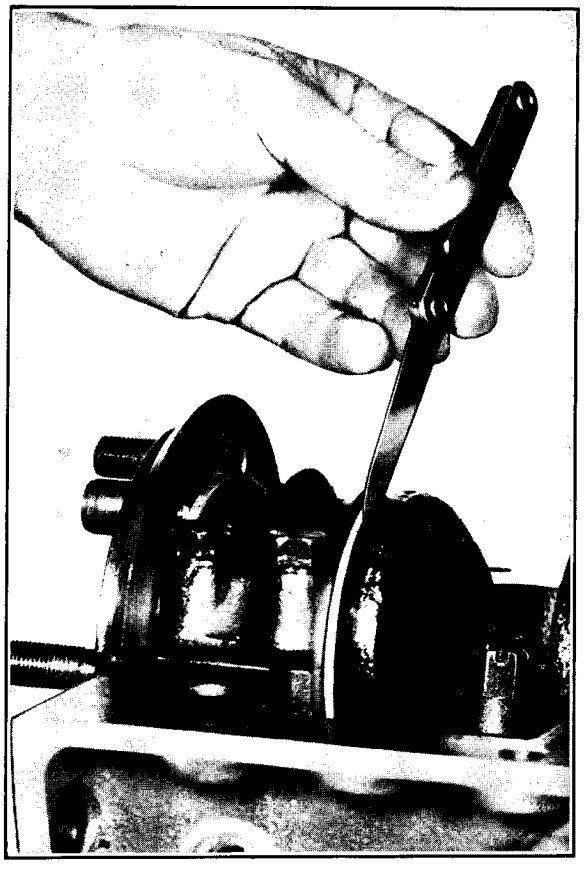

Illustration No. 48

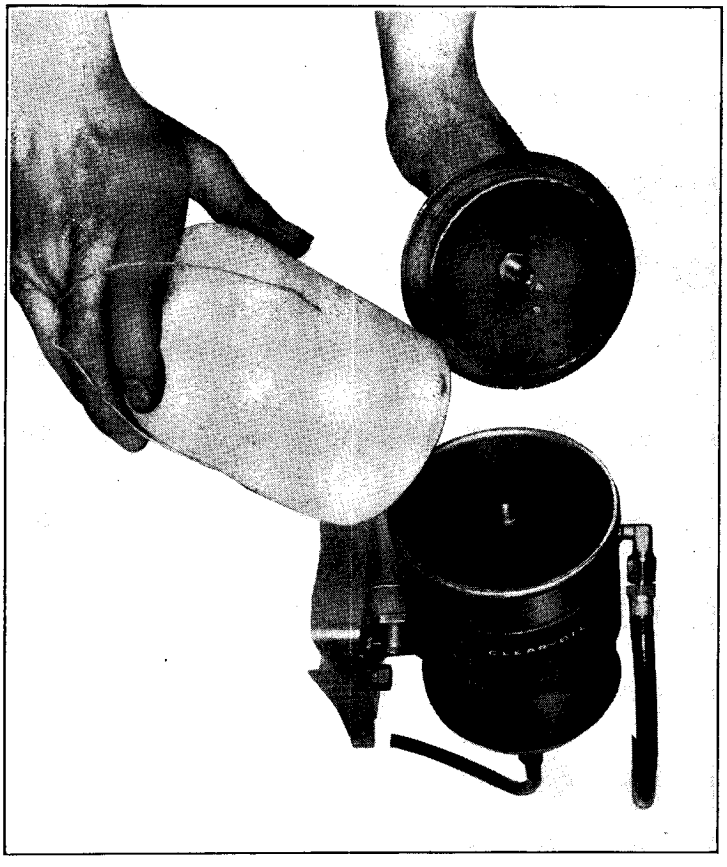

Illustration No. 49

fold stud nuts, a washer should be used under the nut and the manifold progressively tightened from the center to the end, repeating the operation at least three or four times to make sure that the manifold is tight.

In many instances a companion flange and gasket are used for the installation of the exhaust pipe. Be sure these are drawn up tight and square with the manifold flange to avoid leaks.

TO REMOVE MANIFOLD

1. Disconnect fuel lines.
2. Disconnect carburetor controls. Carefully note how controls are assembled so they can be replaced in correct position.
3. Remove air cleaner or air cleaner connections.
4. Remove carburetor.
5. Disconnect crankcase ventilating assembly, if used.
6. Disconnect exhaust pipe from manifold.
7. Remove manifold attaching nuts and washers.

TO INSTALL MANIFOLD ON ENGINE

1. Place manifold gasket on attaching studs and assemble manifold to engine.
2. With the nuts and washers as removed, tighten the manifold into place. Tighten all nuts lightly, then starting from the center, work progressively toward the ends of the manifold, repeating until all nuts are tight.
3. Attach exhaust pipe and tighten screws.
4. If crankcase ventilation valves were removed—reinstall.
5. Connect primer tube, if used, and crankcase ventilation tube assembly.
6. Install carburetors.
7. Install air cleaners or connect air inlet tubes.
8. Connect carburetor controls. Make sure these controls are correctly assembled.
9. Connect fuel lines.

OIL FILTER

When engines are equipped with an oil filter, Illustration No. 49, this unit should be given regular and careful attention. The filter element should be replaced when oil begins to darken. Then add sufficient oil to crankcase so oil level will be correct after engine has run long enough to refill the filter.

ANY TYPE of oil filter must be given intelligent attention, and frequent cleaning if it is expected to remove dirt etc. from the oil. Some filters must be inspected daily—study the service requirements of your particular type and save repair expense.

OIL LINES

Oil lines are usually repaired by replacement, however, there are times when they can be resoldered or brazed.

Illustration No. 50

GOVERNOR LUBRICATING OIL LINE

Since this is an external line a leak will be observed by oil being blown over the engine. If broken, repair or replace. Clean each time engine is overhauled or if governor fails because of lack of lubrication. Be sure to clean before replacing after repairing governor.

OIL PAN

The oil pan serves as a cover for the bottom of the crankcase and also as an oil reservoir.

Suitable drain plugs are located in the bottom of the oil pan. See Illustration No. 50. Bayonet gauge is covered on Page 21.

TO REMOVE OIL PAN

1. Drain crankcase oil.
2. Disconnect starter cable and remove starter. Tape any "hot" cable terminals.
3. Remove bayonet gauge assembly.
4. Remove cap screws from oil pan and lift oil pan away from engine.

TO INSTALL OIL PAN

1. Clean oil pan thoroughly, remove old gaskets. Install baffle plate and strainer.
2. Inspect inside of engine for loose nuts, screws, cotter pins and lock wires.
3. Cement new gaskets in place and allow cement to set so gaskets will not skid. If lower part of bellhousing gasket is damaged, cut at oil pan intersection at block and replace with similar part of new gasket.
4. Put oil pan in place and carefully start all screws. Be sure lockwashers are on screws.
5. Draw up all screws very lightly. Make sure pan is centered at crankshaft oil seal so as not to damage rubber ring.
6. Tighten progressively the five screws in the bellhousing and the three screws next to bellhousing (both sides) in crankcase, alternating between vertical and horizontal screws until tight. This is to pull the corner of the pan in against the corner formed by the bellhousing and cylinder block or crankcase.
7. Check alignment of oil pan at front seal and tighten four cap screws at front in gear cover.
8. Tighten all remaining screws.
9. Put in drain plugs.
10. Reinstall starting motor and cables.
11. Reinstall bayonet gauge assembly.
12. Refill with oil to correct level.

OIL PUMP

There are many different oil pumps used to suit various types of oil pans and types of operation. These include the basic or standard pump shown in Illustration No. 51, and various modifications of this pump.

If the instructions for the dissembling and reassembling of the standard pump, given in the following paragraphs are carefully followed the mechanic should not find it difficult to make repairs on any of the oil pumps.

The oil pump is attached to the cylinder block and its gear is driven by a gear solid with the camshaft and located near the center of the camshaft. The lower end of the oil pump extends down into the oil pan and oil is drawn into the pump through a large screen which prevents coarse dirt being drawn into the lubricating pump. The oil pump extends into the oil, therefore, the pump needs no priming. After the oil pan is removed, the oil pump is readily removed for inspection or repairs. The various parts of the oil pump are shown in Illustration No. 51.

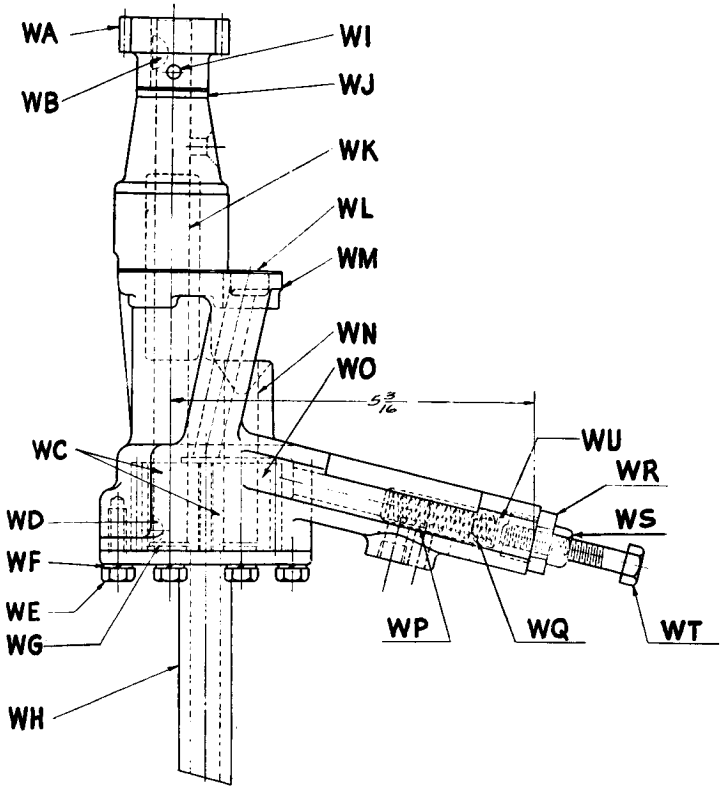

Illustration No. 51

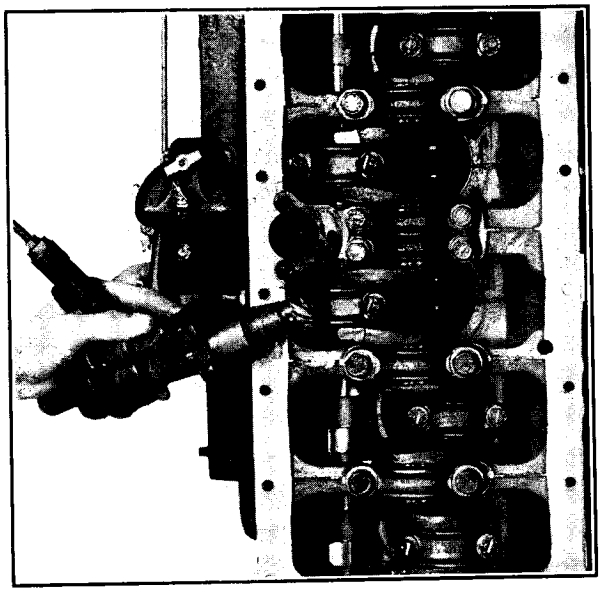

Illustration No. 52

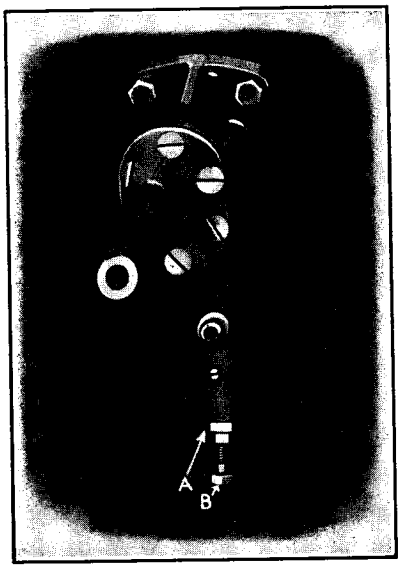

Illustration No. 53

TO REMOVE OIL PUMP FROM ENGINE (See Illustration No. 52)

1. See removal of oil pan, Page 47.
2. Remove pump attaching screws.
3. Pull oil pump out and away from cylinder block. Use care that the pump does not fall out if the engine is in normal position. As the oil pump operates in a bath of oil it seldom needs repair. However, if necessary to disassemble the pump, proceed as follows:

TO DISASSEMBLE OIL PUMP (The following reference letters will be found in Illustration No. 51).

1. Remove pin WI from drive gear WA, pull gear from shaft WK and remove Woodruff key WB.
2. Remove screws WE and pump cover WH.
3. Remove idler gear WO and shaft WN.
4. Pull main shaft WK down through pump body WM to remove it.
5. Press idler gear shaft WN out of gear WO.
6. Press main shaft WK through oil pump gear WC approximately $\frac{3}{8}$" and remove snap ring WG. Then press shaft out of gear.

TO REASSEMBLE OIL PUMP

(Certain operations may be disregarded if pump is not completely disassembled).

1. Insert Woodruff key WD in shaft WK, press pump gear WC on shaft, install snap ring WG then press shaft back so that snap ring seats in gear.
2. Assemble shaft WK in body WM, install thrust washer WJ, insert Woodruff key WB and press on drive gear WA. This shaft must have .0015" to .003" end thrust.
3. Insert drive gear pin WI and pein over ends of pin. (If new shaft is used it must be drilled for pin. Use holes in gear as guide.)
4. Insert idler gear WO and shaft WN.
5. Rotate shaft and check for tight places. Shaft should rotate freely. If pump shaft does not rotate easily, disassemble and check for dirt or chips in gear teeth or between gear ends and body, before proceeding.
6. Install cover and tighten screws then check same as in 5.

TO INSTALL OIL PUMP

1. Put pump in place, using new gasket, securing them with lockwashers and fasten with screws as removed, See Illustration No. 53.
2. Place steel washer and felt washer on pump intake pipe.
3. Install oil pan. See Page 47.

OIL PRESSURE ADJUSTMENT

The oil pressure is automatically controlled or regulated by a compression spring which controls a relief or bypass valve. This device is incorporated in the oil pump. The oil pressure should not be changed or judged to be too high or too low until it is known that the proper weight of oil is being used and the engine is warmed up to normal operating temperature. As the bearings become worn more oil will escape around them into the crankcase and this will lower the pressure slightly. It is not advisable to try to correct this slight loss of pressure by an adjustment of the oil pressure regulator because the extra amount of oil being thrown off by worn bearings is already over oiling the cylinder walls.

Although there are many special specifications as to oil pressure on these engines the most common setting is 26 pounds at 1600 R.P.M. with the oil hot (about 140°F.) which at idling speeds results in a pressure between 5 and 10 pounds. At speeds higher then 1600 R.P.M. the pressure will be higher. When the oil is cold the pressure will be higher. The pressure may also vary with different brands and grades of oil. (On some engines the oil pressure is designated on the engine name plate.) If necessary to change the oil pressure proceed as follows: Remove the pipe plug from the side of the oil pan on the left or side opposite the camshaft. By the use of special wrenches the oil pressure can be adjusted through this opening (see Illustration No. 54). Using the special crow foot wrench loosen lock nut (shown at A in Illustration No. 53) and with the "T" handled socket or screw driver, turn screw (shown at B in Illustration No. 53) in for increased pressure and out for decreased pressure. After the adjustment is made the lock nut must be tightened.

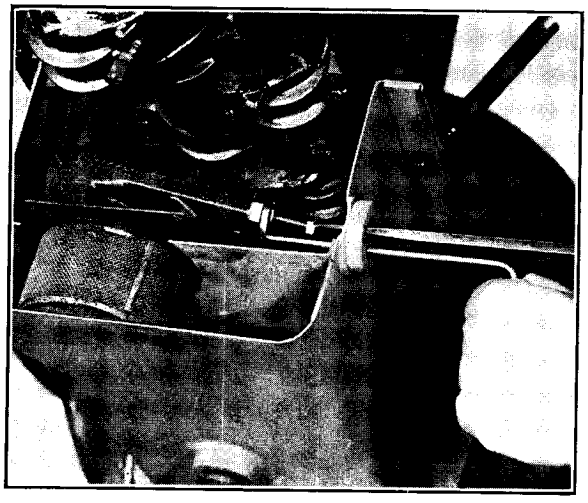

Illustration No. 54

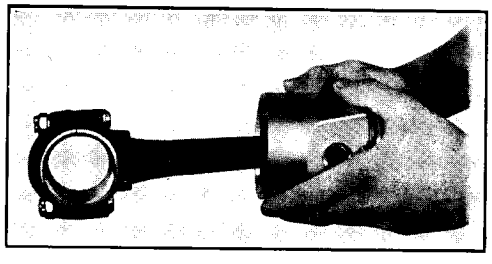

Illustration No. 55

PISTON, PIN AND RINGS

FITTING PISTONS AND PINS

In fitting new or oversized pistons and rings to reground or honed cylinder bores the clearance should be carefully controlled. See table of clearances on Page 62 for various sizes and types of pistons. If a feeler ribbon is used it should be the thickness shown in the minimum column in each case for all cast iron pistons. A slight drag should be felt when pushing the piston through the bore with the feeler ribbon. For aluminum pistons a feeler of thickness shown in maximum clearance column should be used for each size. In other words use a .003″ feeler for cast iron pistons up to and including 3⅜″ sizes and up to and including 3 7/16″ sizes in aluminum.

The piston pins are clamped in the upper end of the rod but must be a proper fit in the piston. In the case of cast iron pistons which have bushings for the pin, the pins should be a light push fit. In the aluminum pistons this must be a closer fit and at ordinary room temperatures it will require a hard push with the palm of the hand to have the proper fit. To make it easier to assemble these parts the aluminum pistons can be heated in boiling water for a few minutes. Turn the notch in the pin in line with clamp screw hole in the rod to prevent damage to the threads of the screw as it is screwed into place. Be sure the screw is up tight and locked in the same manner as when removed. To test the tightness of the piston pin (in aluminum pistons) hold pistons as in Illustration No. 55, the weight of the rod will not turn the pin in the piston, while the Cast Iron piston should rock easily with this same test.

Aluminum pistons must be assembled with the split (or "T" slot) side on the left or side opposite the camshaft (in standard clockwise rotation engines.) This is necessary due to the thrust side or camshaft side having more bearing area than the split side. The aluminum pistons are usually marked with the word "FRONT" indicating the side toward the front of the engine when properly assembled. In counter clockwise rotation engines (marine) using aluminum pistons the split in the skirt will be on the camshaft side. Pistons for counter-clockwise engines will have different part numbers but are the same as standard except for the marking.

PISTON RINGS

When installing new piston rings, each ring should be tried in the cylinder bore to see if it has the correct gap of .015″ to .020″. If necessary to increase the gap the ring should be held and filed as shown in Illustration

Illustration No. 56

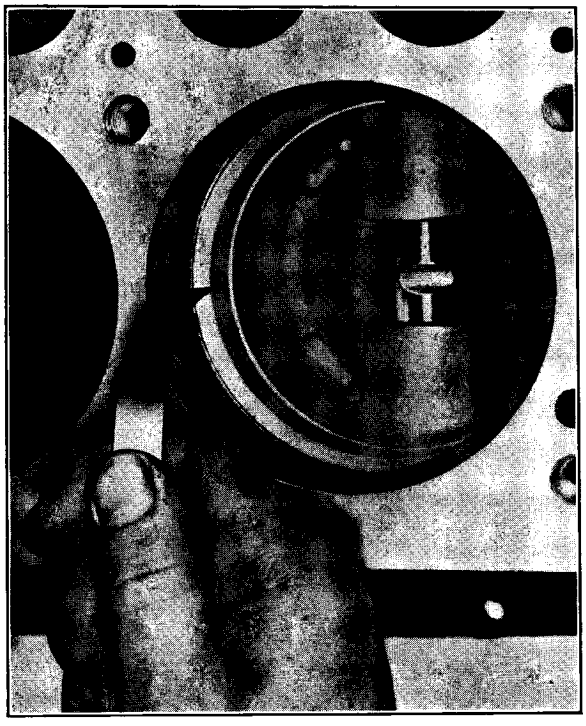

Illustration No. 57

No. 56. If the ring is held in a vise, the vise jaws must be covered with some soft metal. The ends of the rings are squeezed together and the file cuts on both sides. This will insure the ends being parallel. When inserting the ring in the cylinder bore to test the gap clearance, push the ring part way through the bore using the bottom of a piston to square the ring in the bore. Illustration No. 57.

Each new ring should be tried for clearance in the piston groove by rolling the ring all the way around the groove as shown in Illustration No. 58. If the piston grooves have been carefully cleaned the rings will be found to fit correctly, but if they are tight they can be lapped slightly on a sheet of emery cloth (No. .000) laid on a flat surface. Use a light uniform pressure when lapping.

When assembling piston rings to the piston, if a ring spreader tool, Illustration No. 59, is not available the rings can be slipped over thin strips of metal. Whatever method is used the rings must be handled carefully in order not to distort or break them.

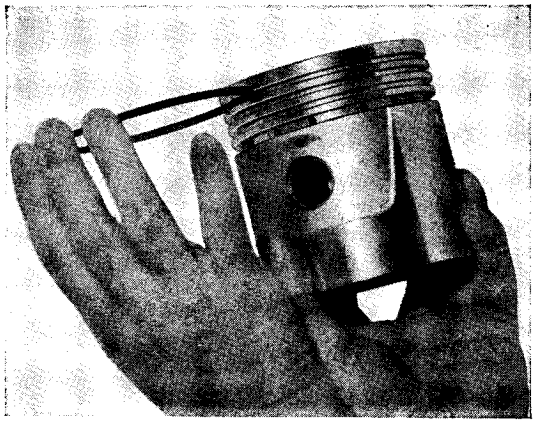

Illustration No. 58

TO ASSEMBLE THE PISTON TO CONNECTING ROD

To make it easier to assemble these parts, the aluminum piston may be heated in a pail of boiling water for a few minutes—this may be disregarded in warm climates.

1. Remove the pin from the piston.
2. Place the connecting rod in position in the piston with the clamp screw hole opposite the slotted side of the piston.
3. Insert the piston pin with the notch in line with the clamp screw hole. A spreader as shown in Illustration No. 60 should be used to spread the rod so the pin may be readily inserted.
4. With the notch in pin lined up with clamp screw hole, remove spreader and assemble clamp screw and lockwasher.
5. Tighten the clamp screw with a firm pull on a 12″ wrench.
6. Check piston and connecting rod for alignment on a standard aligning tool or jig.

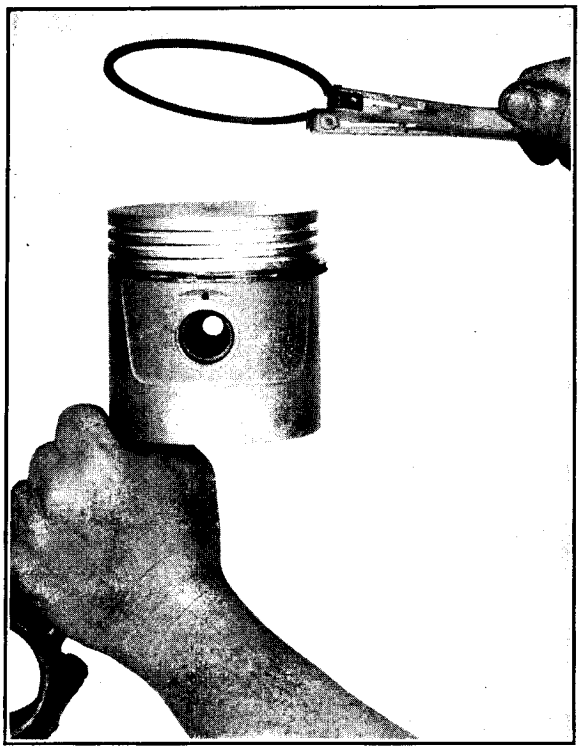

Illustration No. 59

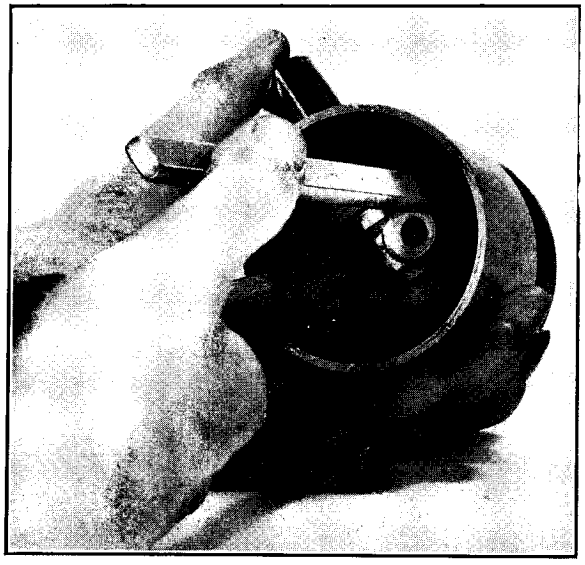

Illustration No. 60

SPARK PLUGS

Spark plug performance has a very important part in engine operation and economy. Therefore, it is important that the correct type of spark plug be selected for your particular engine operation.

Spark plugs are made in various types and each type has a definite purpose which depends on the service required of the engine. For instance, one engine may be operated continually at or near full load and would require a colder type spark plug while another engine of the same type, which is operated at part load or with long periods of idling, would require a hot type spark plug. See Illustration No. 61.

Illustration No. 61 shows a comparison of spark plug types. The cold plug has a low insulator seat which quickly carries away the heat from the insulator and keeps the spark plug insulator and points cooler. This results in longer plug life when the engine is in operation for long periods at full load.

The normal plug has a higher insulator seat which allows the insulator to retain a normal amount of heat. This type plug should be used when the engine is operated at intermediate and variable loads and speeds.

The hot plug has a very high insulator seat, which permits the core to retain the maximum amount of heat. This type of spark plug should be used when the engine is operated at part load with intermittent periods of idling.

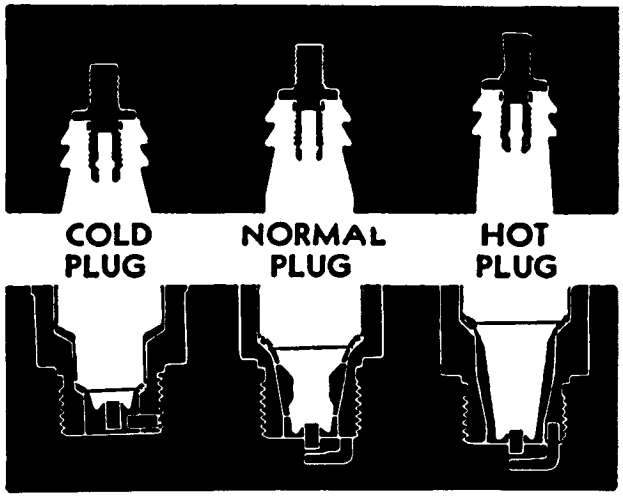

Illustration No. 61

Spark plug maintenance is very simple and easily accomplished and should not be neglected.

After removal of the ignition wires, select the correct size socket and loosen each plug approximately two turns. Then with compressed air or a brush, clean the dirt from around the spark plugs. This is important as the dirt may fall into the cylinders and cause damage when the engine is started.

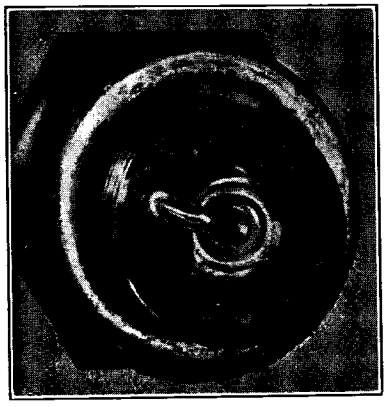

Illustration No. 62

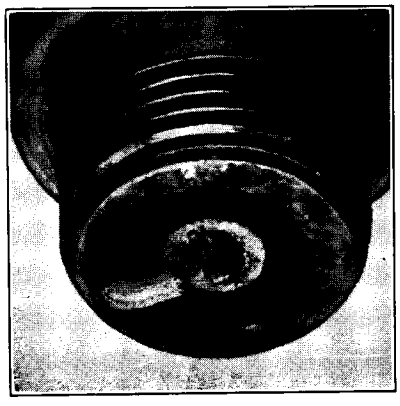

Illustration No. 63

Illustration No. 64

When the dirt has been removed from around the plugs, remove the plugs from the engine and carefully examine the condition of the points and insulator.

A careful study of the following Illustrations and text will explain various spark plug conditions as well as probable causes.

Illustration No. 62 shows the normal condition of plug that has been carefully selected for a particular type of service. Notice the dry, light to dark brown, flaky deposits of combustion products which, when exhibited on each spark plug of a set, indicate a balanced ignition and combustion condition.

Illustration No. 62 shows a burned or overheated spark plug. These are usually identified by dry, shiny, glassy deposits on the insulator, or cracks in the insulator tip, which result from:

1. Too lean an air-fuel mixture.
2. Dirty, clogged radiator or cylinder block and head, or inefficient engine cooling.
3. Broken or slipping fan belt.
4. Too hot a spark plug for the service.
5. Improper installation of spark plugs.
6. Compression leakage through spark plug.

Illustration No. 64 shows a gas fouled spark plug. This condition is usually identified by a black, dry fluffy deposit which results from:

1. Heat range of spark plug too cold for particular service.
2. Prolonged periods of engine idling.
3. Excessive use of choke or improper adjustment of automatic choke.

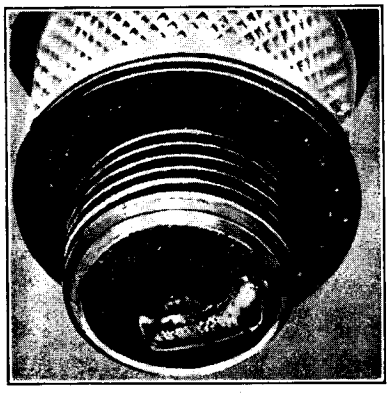

Illustration No. 65

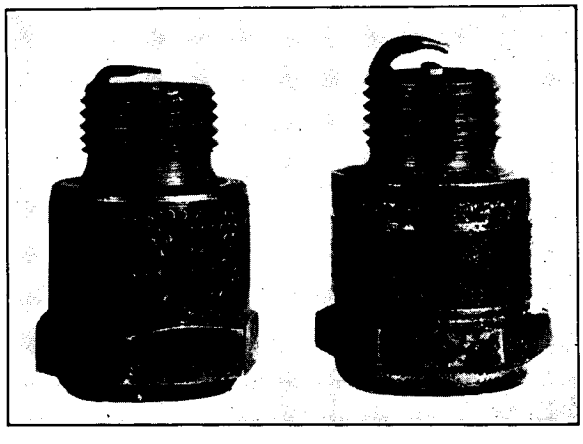

Illustration No. 66

4. Too rich an air-fuel mixture.
5. Spark plug gaps set too close.

Illustration No. 65 shows an oil fouled plug. This condition is usually identified by the wet, black shiny deposit. This may be caused by:

1. Heat range of spark plug too cold for particular type of service.
2. Distributor trouble or faulty ignition cables.
3. Weak coil or battery.
4. Spark plug gaps too close.
5. Worn piston rings or pistons.

Illustration No. 66 shows how the spark plug points wear or corrode with service. The amount of wear indicates the extent of service to which the plug has been subjected. When plugs become worn to this extent, they should be discarded and replaced.

Before reinstalling the spark plugs they should be cleaned and have the point gap adjusted. Always adjust the points by bending the ground electrode. Never attempt to bend the center electrode as this may chip or crack the insulator and render the plug inoperative.

When installing spark plugs, use a new gasket, if available.

The plug is properly tightened when the gasket is compressed to approximately one-half its original thickness when new. If a spark plug is tightened too tight, the body may become distorted and crack the insulator.

If the plug is too loose, it may allow exhaust gases to escape around the threads and at the same time the heat will not be carried away from the plug fast enough to prevent the plug from becoming damaged from excessive heat.

STARTING MOTOR

The starting motor is designed to crank the engine when the switch closes the circuit between the storage battery and the motor. It consists of five main sub-assemblies, the frame and field, the armature, the commutator end head, the pinion housing and the Bendix drive. The frame and field consists of the frame which supports the components of the starting motor, the pole pieces and the field coils. The coils supply the magnetic field which is needed to produce torque; the pole pieces and frame supply the path for the magnetic field. Illustration No. 67 is an assembly drawing of the starting motor.

The armature consists of a soft iron core, a commutator and the windings which are wound in slots in the core and are connected to the commutator. The commutator consists of a number of copper segments insulated from each other and from the armature shaft.

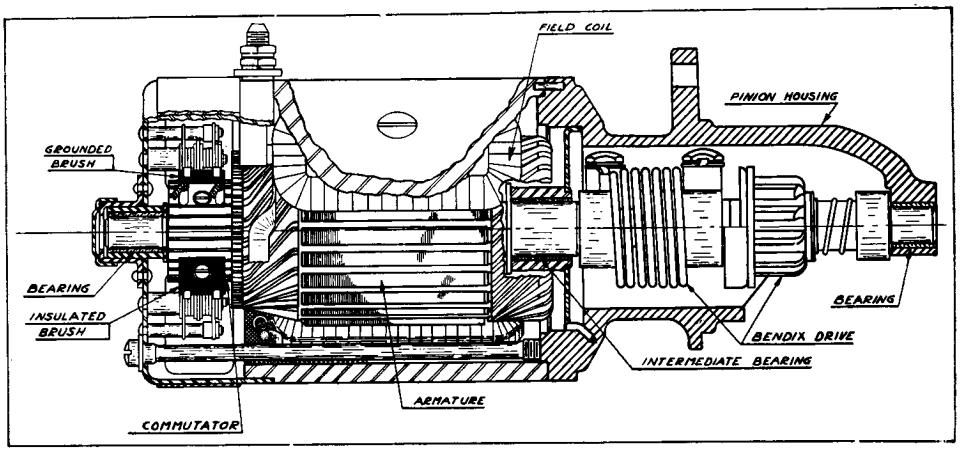

Illustration No. 67

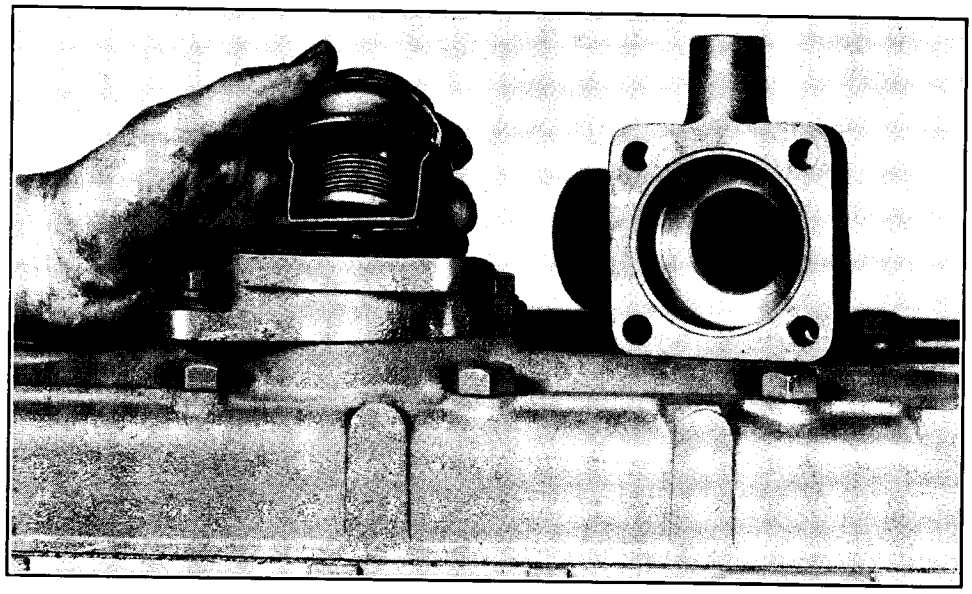

Illustration No. 68

The commutator end head supports a bearing, brush holders and brushes. The pinion housing is a cast iron housing for the Bendix drive and also provides the motor mounting lugs. The Bendix drive is an automatic clutch that engages the starting motor with the engine flywheel when the motor cranks the engine and disengages when the engine starts. It consists of a threaded sleeve fastened to the armature shaft thru a drive spring and a pinion mounted on the threads of the sleeve. When the starting circuit is closed the armature revolves, turning the pinion and forces the gear forward, meshing it with the flywheel gear. The sudden shock of meshing is absorbed by the spring. When the engine starts the pinion is driven faster than the sleeve and is forced back along the threads, automatically demeshing it from the flywheel.

LUBRICATION

Some starters are provided with an oil cup which should be filled with lubricating oil when unit is lubricated.

Other starters have no provision for oiling and these are lubricated at time of overhaul.

After the starting motor has been in service for an extended period it should be removed, dismantled and cleaned. Clean the Bendix drive thoroughly and lubricate sparingly with light oil. Inspect the wiring for loose or corroded connections and for broken leads. Make sure the insulation on the wiring has not become frayed.

THERMOSTAT AND BYPASS

Some engines are equipped with a thermostat Illustration No. 68 so designed that it will not allow water from the radiator to circulate through the engine until the water in the engine is at operating temperature but does bypass a certain amount of water from the cylinder block which is carried through the bypass tube to the inlet side of the water pump where it is again circulated through the engine. This is repeated until the water in the engine is heated to operating temperature, when the thermostat begins to open and permit the water from the engine to enter the radiator. This water is at the same time replaced in the engine by the water pump drawing from the bottom of the radiator. Thus the water temperature is constantly maintained in the proper heat range.

A defective thermostat of this type must be replaced as it cannot be repaired. The thermostat should start opening at 150°±2½° F. and be completely open at 175° in still water test.

The still water test is as follows:

Place approximately 4″ of water in a pan or pail. Insert a thermometer of this heat range in the water and set the thermostat in the water with the bellows submerged. Heat the water slowly and carefully observe when the thermostat valve starts to open and note the water temperature as indicated by the thermometer; continue to heat the water until the thermostat is fully open and again note the water temperature and then compare these temperatures with those given above.

Five degrees above or under those given are permissible.

VALVES

The intake and exhaust valves are made of special steel and operate in valve guides pressed into the cylinder block. They are held on their seats by strong steel springs which are fastened to the valve stem by a suitable spring seat and valve lock arrangement. These valves are operated by the camshaft cams through mushroom type tappets. The replacement of valves and valve guides will be found under the subject of Valve Grinding, see below. The replacement of valve tappets is discussed under the subject of valve tappets starting on Page 57.

VALVE GRINDING

In order to continue to get good performance from an engine it may be necessary to grind or reseat the valves at varying intervals. The frequency for doing this depends on the care in the operation of the engine, but if the instructions in this book are carefully followed the necessity for doing this as well as other service operations will be reduced to a minimum.

The necessity of removing the cylinder head is sometimes due to excessive carbon which makes its presence known by knocking. As this knocking is due to the carbon having partly filled up the combustion space and made the compression too high for the fuel being used, the knocking can be reduced by using a fuel of higher anti-knock qualities. Eventually, though, it will be necessary to remove the cylinder head and clean out the carbon and it is a good policy to examine and reseat the valves while the head is removed.

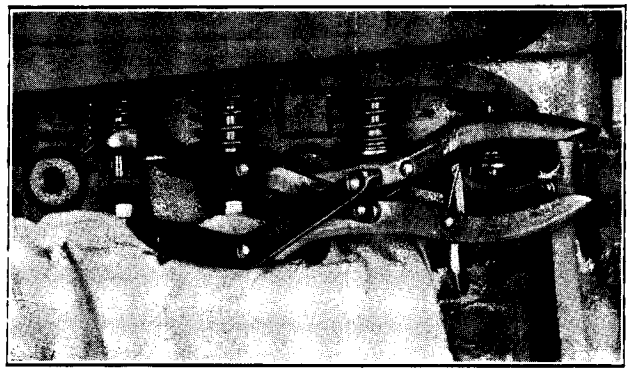

Illustration No. 69

At other times the necessity for removing the cylinder head may be due to one or more leaking valves which will cause an engine to miss fire while pulling a load at low speeds and also may be detected by rocking the engine against compression on each cylinder in turn with the starting crank. When testing the compression in this manner have the ignition off and the throttle wide open to allow a full charge of air to enter the cylinders.

Assuming that the carbon is to be cleaned out and the valves ground, we suggest several important steps in the general procedure.

1. Remove cylinder head, see Page 31.
2. Remove crankcase ventilation tubes, if used.
3. Remove tappet covers.
4. With a conventional type valve spring lifter, compress the valve springs and remove the valve seat locks. Pack the holes in the lower part of valve tappet chamber with rags to prevent locks from falling into oil pan. See Illustration No. 69.
5. Lift out valves and place them in a cardboard or wood block drilled and numbered so that valves may be reinstalled in their respective places when grinding or reassembling. (Do not mark valves with file or punch).
6. Clean all carbon from cylinder head, piston heads, valve seats, valve guides and valves with suitable scraping or buffing tools.
7. Inspect the valve guides for excessive wear. If the valve guides are to be renewed, this should be done before any work is done on the valve seats. This will insure the seat being finished square with respect to the new guide. The exhaust valve guides will usually show the most wear. To allow space in the valve chamber for driving out the old guides, remove valve springs and run the tappet adjusting screws all the way down and crank engine so tappet is on low part of cam. To drive out guides, use a drift $\frac{1}{2}$" diameter with $\frac{5}{16}$" diameter pilot. Drive in new guides to the same depth location as old guides. After new guides are driven in they must be reamed to size on the inside diameter to correct any squeezing in or possible distortion due to being driven into place. This is important in order to get a proper fit and the proper clearance. See Table of Clearance, Page 62.
8. Inspect valve seats and if they are pitted or if new guides have been installed the seats should be refinished. Valve seat tools with $\frac{5}{16}$" diameter pilots are required. The exhaust valve seats are finished on a 30° angle and should have an even width all the way around. The intake valve seats are also finished on a 30° angle.

9. Inspect valves carefully and if the stems are badly worn or are not straight, the valves should be replaced by new ones. However, valves that are only slightly pitted can be used by refacing them on a valve face grinder. Valves must have an accurately finished face of the correct angle. See table on Page 62 for seat face width.
10. Grind or lap each valve to its seat. Be sure the tappet is in such a position that it does not hold the valve off its seat. Use a light coil spring under each valve as it is being lapped in, to raise the valve off its seat during the process. Use a medium grade compound and using only a light pressure rotate the valve only part of turn with a suitable valve grinding tool before raising it off its seat and rotating while off to a new position before again lightly bringing it against the seat for another part of a turn. Avoid continuous round and round motion that would cut grooves in the valve or seat. Repeat this process of lapping, until a bright silver-like band of uniform width is produced on valve and seat, then clean off all traces of the compound and test each valve for a tight seat by making pencil marks across the face of the valve at short intervals and then rotate the valve against its seat for part of a turn and with a firm pressure and again lift out and observe if the pencil marks are all rubbed out on the contact surface; if not, regrind until this test shows a gas tight mating of valve and seat. It is imperative that the valves be assembled in the same seats to which they were ground.

TO REASSEMBLE THE VALVES

1. Clean all traces of grinding compound off of valve stems and guides and put a few drops of oil on the valve stems and insert valves.
2. Pack the holes in the lower part of valve tappet chamber with rags to prevent any locks from falling into the crankcase.
3. Use lifter as in Item 4 Page 55 to compress valve springs and insert valve locks.
4. Remove the rags that were used for packing.
5. Adjust tappets as shown in Illustration No. 74 to approximate setting, refer to Section on "Valve Tappets."
6. Install cylinder head and other parts, see Page 32.
7. Fill cooling system with water or cooling solution.
8. Start and warm engine to operating temperature.
9. With the engine idling slowly, adjust tappets to correct clearance, see section below.
10. Assemble the valve covers (use new gaskets) and crankcase ventilating tubes (if used).

VALVE — ROTATOR TYPE

GENERAL DESCRIPTION

Some engines are equipped with Eaton valve rotators which consist of a special spring seat retainer "A," a cap "B," a pair of flat half-round keys "C" and a special valve stem shape "D." The normal tappet lash as shown on the engine name plate is maintained to accommodate valve expansion. Illustration No. 70.

At the beginning of the valve lift the tappet first lifts the cap "B" through the rotator clearance and lifts the spring seat "A" through contact with keys "C" leaving valve free to rotate.

During the lift cycle the valve motion is controlled but the valve is not located in any way which would prevent turning. The natural vibrations of the valve train, the flow of the gases around the valve head and the slight rotating motion imparted by the spring cause the valve to rotate slowly a small fraction of a revolution each lift cycle.

INSTALLATION AND SERVICE

The rotator parts as furnished are made to be interchangeable when new and unused. However, it is wise to check the rotator clearance after assembly to insure rotation. Be sure valve and rotator parts

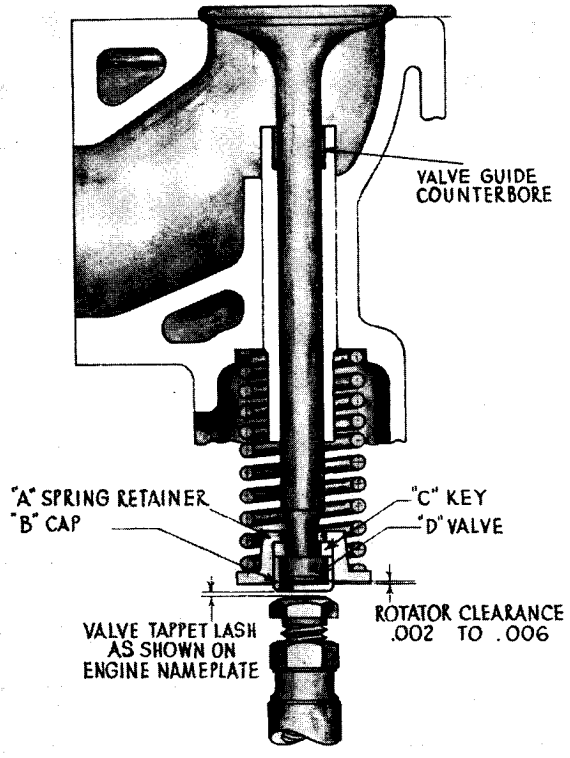

Illustration No. 70

are clean. Precaution should be taken against nicking the valve tip or rotator parts when assembling or handling as this may cause a lack of clearance. BE SURE WHEN SERVICING TO KEEP ROTATOR PARTS WITH THEIR RESPECTIVE VALVE. THIS WILL SAVE UNNECESSARY WORK IN TRYING TO REFIT PARTS.

If no clearance exists after assembly remove all parts and give clearance by removing stock from the tip of the valve. If clearance is too great remove enough stock from the top face or rim of the cap to reduce it to the proper limits. (To remove stock either grind or lap on fine emery cloth or oil stone.) Illustrations No. 71 and 72.

The rotator clearance when the parts are assembled in the engine should not exceed .006" or be less than .002". To check clearance turn the engine to raise valve from seat. The valve should turn freely and clearance can be checked by indicator reading on valve head when valve is moved vertically. Illustration No. 73.

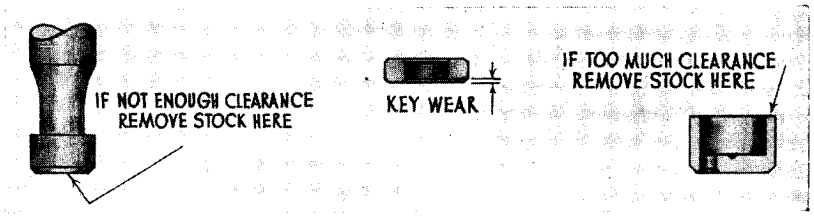

Illustration No. 71

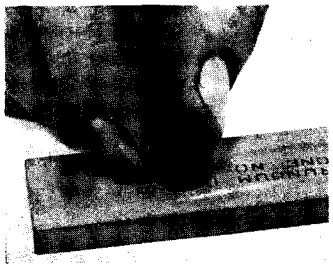

Illustration No. 72

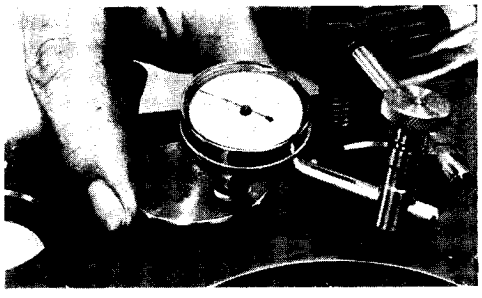

Illustration No. 73

ONCE PARTS HAVE BEEN FITTED THEY SHOULD BE KEPT TOGETHER AS SETS AND SHOULD NOT BE INTERCHANGED. After being in service the faces of the keys may show signs of slight wear. This wear is not harmful, providing the rotator clearance is still within the recommended limits. Be sure when reinstalling the keys to get both parts of a set in position with the wear facing in the same direction in order not to cause cocking of the spring washer. As a final check, rotate the engine until each valve is lifted from the seat in which position it should turn freely, recheck rotator clearance.

VALVE TAPPETS

The valve tappet assembly is the mushroom type and consists of three pieces; the valve tappet or push rod, valve tappet screw and valve tappet screw lock nut. When these three parts are assembled together they form the complete tappet with the mushroom riding the cam on the camshaft and the head of the tappet screw in contact with the valve stem. These operate in cast iron bushings pressed into the cylinder block.

TO REPLACE VALVE TAPPETS

1. Remove camshaft. See Page 23.
2. Remove tappet from cylinder block.
3. Check the tappet screws for wear and replace any which have started to cut or hammer out.
4. Check tappet clearance in cylinder block. This should be approximately .001". However, it will be necessary to change tappets if this clearance is slightly greater.
5. If necessary to replace tappet, try a new tappet for clearance and if the clearance is still too great it will be necessary to replace the tappet bushings.

TO REINSTALL TAPPETS

1. Assemble tappet screws and nuts, and insert tappets in cylinder block.
2. Reassemble the camshaft. See Page 23.

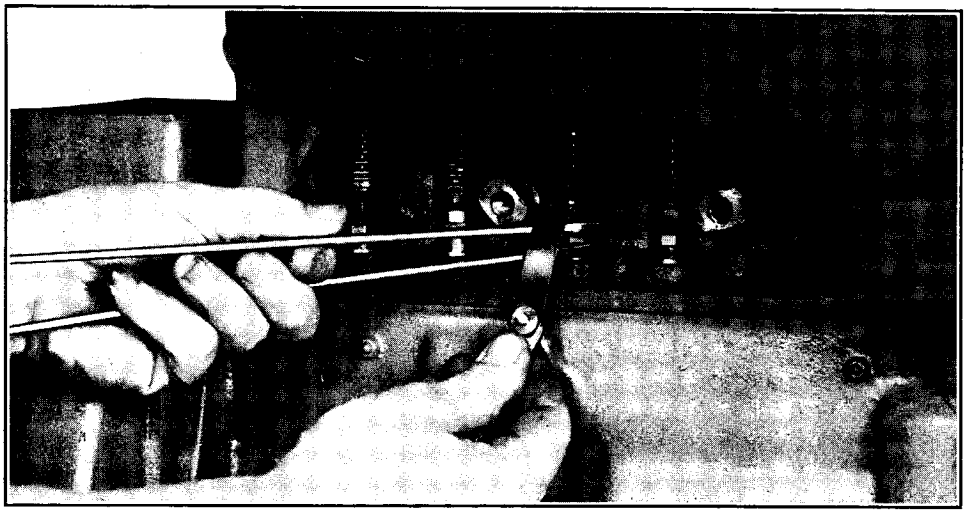

Illustration No. 74

3. Adjust tappets for each of the cylinders, setting them for at least .007″ clearance on the intake and .010″ clearance on the exhaust. After the engine has warmed up and while running at idle speed, check and reset tappet clearance, Illustration No. 74, to clearance as shown on Serial Number Plate on Crankcase.
4. Replace tappet covers.

WATER PUMP (Blind End Type)

Illustration No. 75 shows a longitudinal section through the water pump commonly used with distributor ignition. It is of the packless or auto seal type. This pump may be readily removed from the engine after the cooling system is drained. Remove water discharge pipe, water inlet pipe, disconnect primary wire from distributor and remove distributor cap, then remove three capscrews holding water pump to cylinder block. The water pump can now be pulled back out of the cylinder block.

TO DISASSEMBLE THE PUMP:

1. Remove screws **X** and lockwashers **Y** then pull cover **U** away from cradle **F.**
2. Remove impeller pin **S.**
3. With suitable support under pump attaching flange, press shaft **B** out of the impeller **T.** Be careful shaft does not fall out of pump cradle and damage the gear, etc.
4. Remove shaft **B** from cradle **F.**
5. If it is necessary to replace the distributor drive gear **I,** it may be removed from the shaft with a drift punch after the snap ring **J** is removed.
6. Press drive gear **D** from shaft and remove Woodruff key **C.** If necessary to remove thrust plug **A** refer to 7 on Page 22.
7. Remove snap ring **L** from impeller **T** and remove seal parts **R.**
8. To remove the split type bushing **V** from cover **U,** drive a small chisel along one side of split line. This will force one side, loosening the bushing, which will either drop out, or can be pulled out with a pair of pliers.
9. To remove bushing **G,** a driver (13234-A) should be used. Drop plate through bushing and locate in inner end of bushing then insert driver shaft through pump and press out bushing.
10. Remove oil seal **K** from cradle.

TO REASSEMBLE THE WATER PUMP:

1. Press new bushing **G** into cradle.
2. Install woodruff key **C** and press shaft **B** into gear **D,** then press in thrust plug **A.**
3. Install woodruff key **H,** press on distributor gear **I** and insert snap ring.

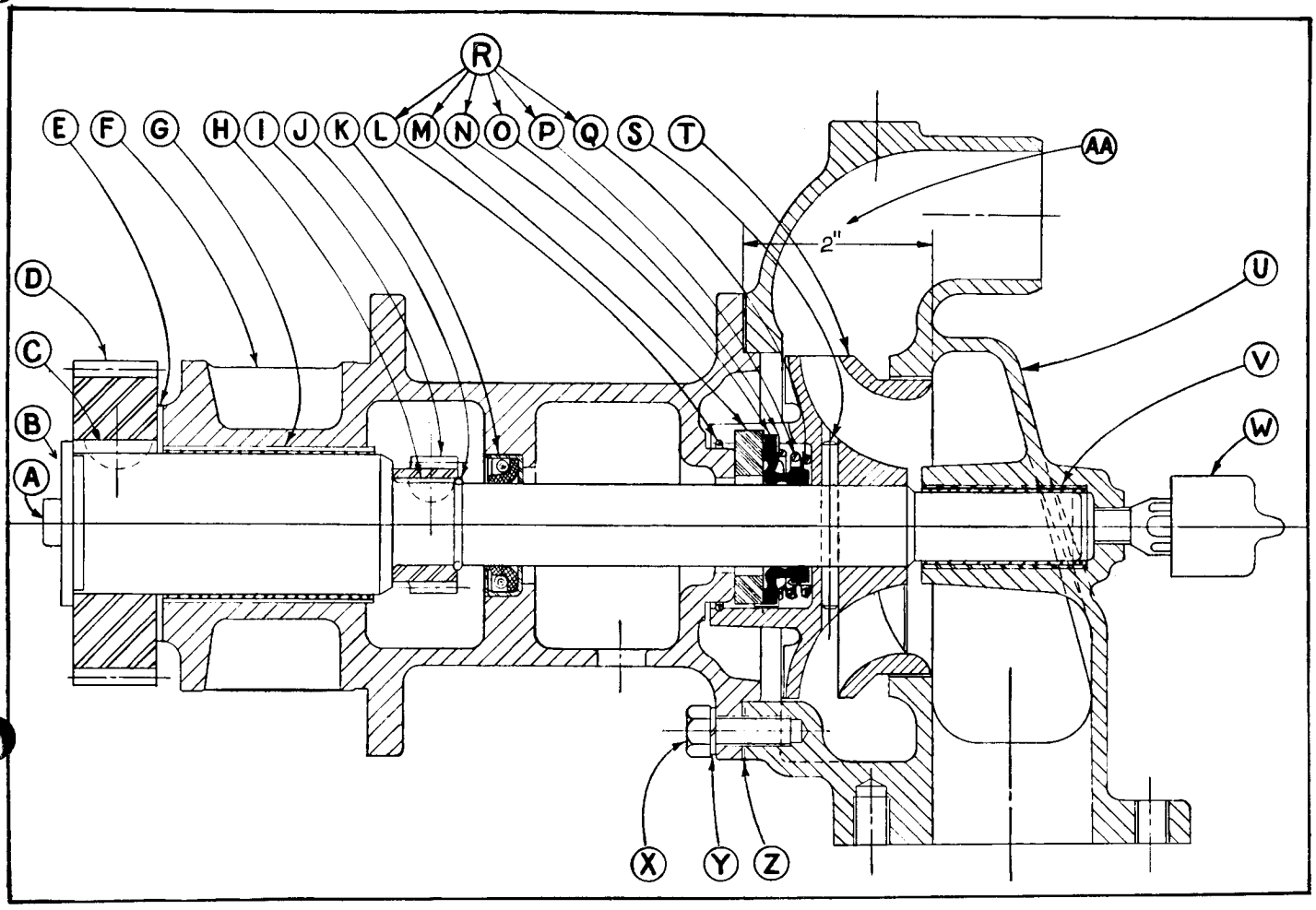

Illustration No. 75

4. Fit shaft into cradle bushing and check clearance. This should be .0015″—.0025″.
5. Install new oil seal **K** in cradle. Be sure lip of seal is toward front or gear end of cradle.
6. Place thrust washer **E** on shaft and insert shaft into cradle sleeve. Be very careful that oil seal is not damaged when assembling the shaft. A special tool (Part No. 6372-A) is available from Hercules Motors Corporation for installing the shaft.
7. Assemble new seal assembly **R** into impeller, locking assembly into place with snap ring **L**. Wipe shaft lightly with tallow or other light grease and press impeller into position on shaft. If old impeller and shaft are used, line up holes in impeller with hole in shaft and drive in new pin **S**. If new shaft, or new impeller is used it will be necessary to position impeller on shaft as shown at **AA**, and then drill a hole through the impeller, or shaft, or both for the impeller pin. Install new pin and stake or pein both ends.
8. Press new bushing **V** into cover **U**.
9. Place new gasket **Z** on cradle and install cover **U**, tightening into place with screws **X** and lockwashers **Y** as removed.

WATER PUMP (Through Shaft Type)

This water pump shown in Illustration No. 76 is used with magneto or distributor or both. The water pump is of the centrifugal type and is composed of two sub-assemblies; one, the water pump drive which is mounted in the cylinder block and is driven from the timing gears; two, the water pump proper which is coupled to the drive with suitable internal gears. The two sub-assemblies are held together with the screws used to attach the complete assembly to the engine.

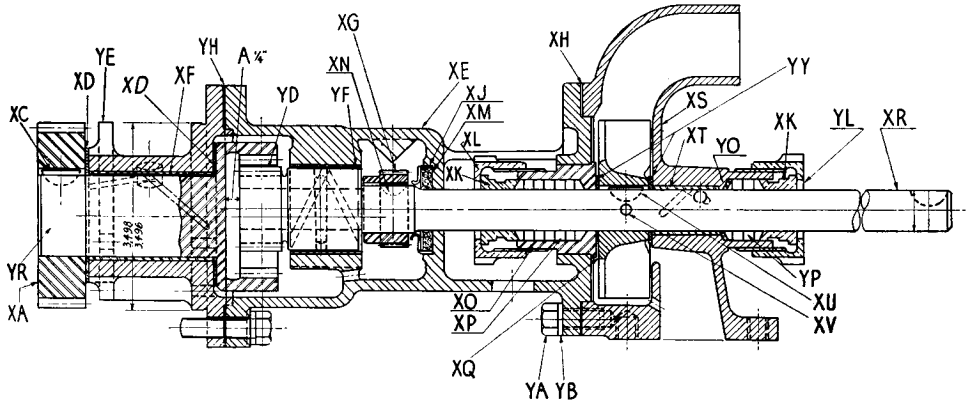

Illustration No. 76

Before installing the distributor or tachometer drive in a new engine or after a prolonged shutdown, ½ cup of lubricating oil should be poured into the distributor opening before starting the engine.

Some engines have an external oil line which carries lubricating oil under pressure to the water pump. When engines are equipped with this line the above paragraph may be disregarded.

TO DISASSEMBLE THE WATER PUMP. (Illustration No. 76 unless otherwise noted).

1. Remove water pump drive from pump cradle. Remove magneto drive coupling and Woodruff key. Remove the rear packing nut YL, gland XK and packing YP.
2. Remove the four cap screws YA holding body or impeller cover XS to the cradle XE and remove body and gasket from cradle.
3. Remove impeller pin XV with pin punch and pull impeller XQ from the shaft XR. CAUTION: Do not press shaft through impeller as key XU will damage the front packing gland or bushing YY. If no puller is available the impeller may be removed in the following manner.
   Press the shaft through the impeller ⅛" then place a suitable spacer between the impeller and bushing. Press the shaft through the impeller until the key almost touches the bushing, then add more spacers. Repeat until impeller is removed.
4. Remove impeller key XU and pull shaft from cradle.
5. Unless the distributor gear XG is damaged or worn, it is not necessary to remove it. If damaged, drive gear off with a drift punch and remove key. NOTE: Further disassembly of this shaft is not practical as the shaft is assembled before the final cutting of the gear teeth and grinding of the shaft.
6. Turn water pump drive gear key XC so that it is in line with notch in housing, see Illustration No. 77 and press shaft YR through gear and thrust washer XD until key XC almost touches the bottom of the notch then put spacers between gear and housing and continue to press shaft out of gear. Repeat if necessary so that sleeve or housing bushing is not damaged. After gear is removed pull key from shaft and remove shaft from sleeve.
7. Press bushing out of sleeve.
8. To remove split type bushing YF in body, drive a small chisel along one side of split line. This will force one side in, loosening the bushing, which will either drop out, or can be pulled out with a pair of pliers.
9. To remove rear cradle bushing XO or packing gland, screw packing nut XL on bushing. Lay a flat piece of steel across this nut and drive, or press bushing out of cradle.
10. Drive out cork oil seal XM and retainer XJ with a punch.

TO REASSEMBLE THE WATER PUMP. (Illustration No. 76.)

1. Press drive sleeve bushing XF in sleeve YE. Check drive shaft YR clearance in bushing. The correct clearance is .0015"—.0025".

2. Put thrust washer XD on shaft YR and place shaft in sleeve YE. Install second thrust washer XD, and drive in gear key XC.
3. With a .003″ feeler gauge on thrust washer press drive gear XA on shaft. The gear should be pressed on until a light pull is necessary to remove the feeler. This should allow the drive shaft to have .003″ end clearance in the sleeve.
4. Press bushing YF in cradle XE, and bushing XT in body XS. Check shaft clearance with .0015″ feeler gauge, if necessary, ream or burnish to size.
5. Install distributor drive gear key XN and press on gear XG.
6. If the packing gland or bushing XO has been removed from the cradle, cover contact surfaces with white lead or plastic type sealing compound and press into cradle.
7. Remove any nicks on water pump shaft XR. Slide it through front cradle, and then through packing nut XL, packing gland XK and packing XP, before the shaft goes through the rear cradle bushing XO.
8. Put thrust washer YY on shaft and install impeller key XU.

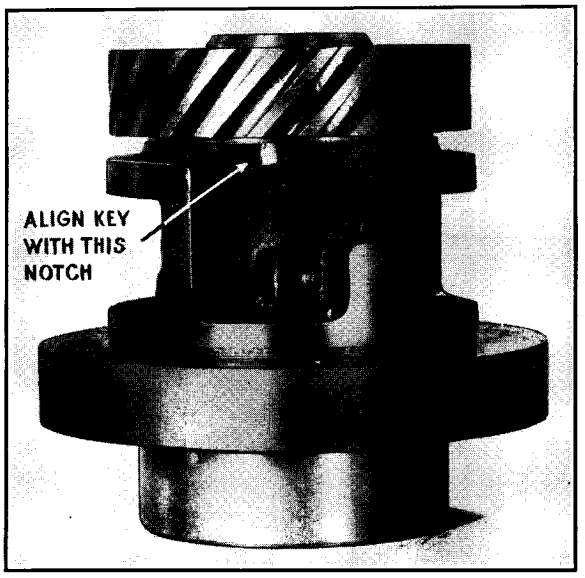

Illustration No. 77

9. Before pressing impeller XQ on shaft XR, position shaft so that front face of gear is ¼″ from front flange of cradle. Use a ¼″ flat steel plate about 1½″ square placed on end of gear, so that shaft will be correctly positioned when the assembly is placed on bed of press.
10. Press impeller XQ on shaft, using a .003″ feeler gauge between impeller XQ and thrust washer YY to check end thrust. Drill impeller XQ and shaft XR and drive in impeller pin XV, make sure it is tight. Put second thrust washer YY on impeller and cement body gasket XH to cradle.
11. Install water pump body XS, use screws YA and lockwashers YB, tightening screws progressively.
12. Install steel packing gland washer YO, packing YP, gland XK and nut YL.
13. Force packing YP into cradle bushing and tighten nut finger tight.
14. Place new gasket on front of drive assembly and assemble in block then place new gasket YH on rear of drive and assemble pump to drive, fastening with screws and lockwashers as removed.
15. Install water inlet pipe and radiator hose, also water pump discharge pipe and hose.
16. Fill cooling system with water or anti-freeze solution.
17. Install magneto. See Page 43.
18. Start engine and tighten water pump packing nuts sufficiently to stop water leaks. DO NOT tighten packing nuts excessively.

GOOD TOOLS

help Competent Mechanics do a better job.

MINOR ADJUSTMENTS

help to maintain the engine in good condition which alleviates major repairs and prolongs its usefulness.

CLEARANCE TABLE

(All Dimensions in Inches)	QX SERIES Min.	Max.
Valve seat diameter—exhaust	1¼	
Valve seat diameter—intake	1⅜	
Face of valve seat—exhaust	3/32	⅛
Face of valve seat—intake	3/32	⅛
Valve stem clearance in guide, Std.	.002	.0025
Valve stem clearance in guide, Marine and Fire Engine—exhaust	.0025	.003
Valve stem clearance in guide, Marine and Fire Engine—intake	.001	.0015
Valve tappet clearance—See instruction plate on engine.		
Push rod or tappet clearance in guide	.00075	.001
Idler bearing (shaft) clearance	.00075	.001
Camshaft bearing clearance	.0015	.0025
Accessory or water pump shaft clearance	.0015	.0025
Crankshaft main bearing clearance—babbitt lined shell	.002	.003
Hi-lead bronze shell	.0035	.004
Connecting rod bearing clearance—babbitt lined shell	.001	.0015
Hi-lead bronze shell	.0015	.002
Crankshaft thrust clearance	.002	.004
Connecting rod side clearance	.005	.010
Bellhousing clearance of chamfer	.012	.025
Accessory or water pump shaft end thrust	.002	.003
Accessory or water pump gear back lash to idler gear	.002	.004
Camshaft gear back lash to crankshaft	.000	.002
Idler gear back lash to camshaft	.0005	.0015
Oil pump gear back lash to camshaft	.008	.010
Piston ring gap	.015	.020
Piston ring land clearance	.0015	.003
Piston pin clearance	Cast Iron Piston	
	.00075	.001
	Aluminum Piston Hand Push Fit	

PISTON CLEARANCE (All Models)

Model	Cast Iron Piston		Alum. Piston	
QXA-3	.003	.0035	.0025	.003
QXB-3	.003	.0035	.0025	.003
QXC-3	.003	.0035	.0025	.003
QXD-3			.0025	.003
QXLD-3			.003	.0035
QXA-5	.003	.0035	.0025	.003
QXB-5	.003	.0035	.0025	.003
QXC-5	.003	.0035	.0025	.003
QXD-5			.0025	.003
QXLD-5			.003	.0035

TORQUE WRENCH TENSION

	Foot Pounds
Cylinder Head Screws (8-10-12-14-15-17-18-20-22-24-Illustration No.25)	80
Cylinder Head Screws (All others)	90
Cylinder Head Stud Nuts	60
Connecting Rod Nuts	39
Main Bearings—Front and Intermediate	70
Main Bearings—Center and Rear	60

QX TOOLS

PART NO.	PART NAME	WHERE USED
3109-A	3/4" Socket	Bellhousing Front & Inter. Main Bearings Cylinder Head, Valve Cover Water Pump Outlet or Oil Filter Flywheel, Fan Bracket
3171-A	5/8" Socket	Connecting Rods Center & Rear Main Bearings
3170-A	9/16" Socket	Oil Pan, Gear Cover Water Pump, Piston Pin Lock Oil Pump Distributor Bracket Water Inlet & Outlet Flanges Starter Attachments
11462-A	1/2" Socket	Fuel Pump
2245-B	1/2" Square Speeder Handle	To be used with the above sockets
3168-A	Socket Extension 6"	To be used with the above sockets
2252-A	Speed Wrench Universal	To be used with the above sockets
13078-A	9/16" x 5/8" Open End Wrench	Water Pump, Oil Pan, Gear Cover Water Inlet & Outlet Flanges Oil Pump, Carburetor, Fuel Lines Manifolds (Intake & Exhaust)
11916-A	1/2" Open End Tappet Wrench	Tappets
3777-A	1/2" Open End Tappet Wrench	Tappets
3256-A	1/2" Open End Wrench	Water Pump, Oil Pump, Fuel Pump
2268-A	Oil Adjust. Crowfoot Wrench	Oil Pump
3177-A	5/8" x 3/4" Open End Wrench	Oil Pan, Bellhousing Valve Cover, Oil Pump
6359-A	5/8" x 5/8" Angle Wrench	Manifolds
3189-A	1/2" Service Ratchet	To be used with sockets
11927-A	Flex Handle	To be used with sockets
2253-A	Connecting Rod Spreader	To install Piston Pins
11924-A	Piston Ring Compressor	Used in installing pistons
13341-A	Valve Spring Lifter	
6286-A	Valve Guide Driver	To remove or install valve guides
6629-A	Push Rod Guide Driver	To remove and install push rod guides.
6624-A	Idler Bushing Puller	Removing idler bushing
13232-A	Idler Bushing Driver	Installing idler bearing
13564-A	Cam Bearing Driver	Removing and installing camshaft bearings.
3296-A	Spanner Wrench	Water Pump Packing Nut
6453-A	Valve Guide Reamer	
6454-A	Valve Guide Reamer Handle	
13098-A	Piston Ring Expander	
11925-A	Screw Driver 3/16" x 5" blade	
13175-A	Screw Driver 1/4" x 6" blade	
13095-A	Pliers—9" Heavy Duty	
13278-A	Adjustable Wrench—8"	
11919-A	Feeler Gauge Set—9" Blades	
11920-A	Lady Foot Pry Bar.	
11921-A	Ball Pien Hammer 12 oz.	
6335-A	Tool Box	
3444-A	Torque Wrench	

Section and Group Index

Section and Group Index (Continued)

HERCULES MOTORS CORPORATION

CANTON, OHIO

Hercules Motors Corporation is a Member of the Internal Combustion Engine Institute and is pleased to warrant all Hercules products sold by it in accordance with the following Basic Warranty adopted by the Institute May 8, 1947, which is subject to future amendment without notice. This warranty is in lieu of any warranty expressed or implied by law and supersedes any different warranty in customer's purchase orders.

BASIC WARRANTY

The Manufacturer warrants each new engine sold by the Manufacturer to be free from defects in material and workmanship for six (6) months from date of shipment, but not to exceed ninety (90) days of service, or such other period of time as may be agreed upon in respect to the application in which the engine is used. The obligation under this Warranty, statutory or otherwise, is limited to the replacement or repair at the Manufacturer's factory or at a point designated by the Manufacturer, of such part as shall appear to the Manufacturer, upon inspection at such point, to have been defective in material or workmanship.

This Warranty does not obligate the Manufacturer to bear the cost of labor or transportation charges in connection with the replacement or repair of defective parts, nor shall it apply to an engine upon which repairs or alterations have been made unless authorized by the Manufacturer.

The Manufacturer makes no Warranty in respect to trade accessories, such being subject to the Warranties of their respective Manufacturers.

The Manufacturer shall in no event be liable for consequential damages or contingent liabilities arising out of the failure of any engine or parts to operate properly.

No express, implied or statutory Warranty other than herein set forth is made or authorized by the Manufacturer.

New service parts are sold subject to the same warranty as new engines.